Vicious cycle of poverty and environmental degradation: Haiti

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The economics of ecosystems & biodiversity

An interim report

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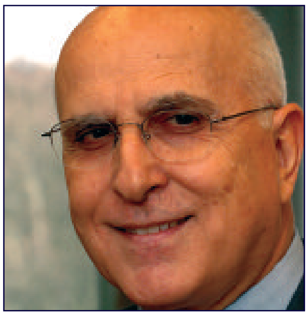
FOREWORD



Biological diversity represents the natural wealth of the Earth, and provides the basis for life and prosperity for the whole of mankind. However, biodiversity is currently vanishing at an alarming rate, all over the world. We are, so to speak, erasing nature's hard drive without even knowing what data it contains. The aim of the Convention on Biological Diversity (CBD) and its 190 Contracting Parties is to significantly reduce the loss of biodiversity by 2010. This is an ambitious goal which can only be achieved through the concerted efforts and combined strength of all sections of society. We therefore need both national and international alliances between policy makers, science, the public and business.

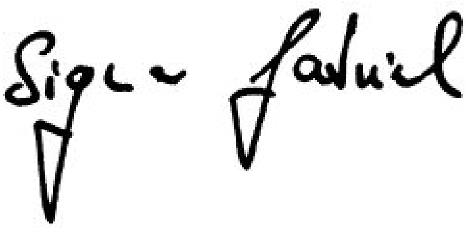
Arising out of a discussion at the meeting of G8+5 environment ministers which took place in Potsdam in May 2007, we decided to launch a joint initiative to draw attention to the global economic benefits of biodiversity and the costs of biodiversity loss and ecosystem degradation.

The success of this joint initiative was always going to be highly dependent on the quality of the leadership and for this reason we have been particularly pleased that Pavan Sukhdev, a Managing Director in the Global Markets division at Deutsche Bank, and founder-Director of a "green accounting" project for India, has accepted to take on the role of Study Leader.

Pavan Sukhdev and his team have had an extremely challenging task to bring together a lot of information in such a short time. Fortunately, they have benefited from the support and contribution of many international organizations as well as prominent experts.

The results from Phase I of the initiative we launched in Potsdam a year ago will be presented at the high-level segment of CBD COP9. We invite and encourage CBD Member Countries and international organizations to contribute actively to Phase II of this work which will begin immediately after COP9.

Stavros Dimas
Commissioner for Environment
European Commission



Sigmar Gabriel
Federal Environment Minister
Germany

PREFACE

Pavan Sukhdev, Study Leader

Not all that is very useful commands high value (water, for example) and not everything that has a high value is very useful (such as a diamond).

This example expresses not one but two major learning challenges that society faces today. Firstly, we are still learning the "nature of value", as we broaden our concept of "capital" to encompass human capital, social capital and natural capital. By recognizing and by seeking to grow or conserve these other "capitals" we are working our way towards sustainability.

Secondly, we are still struggling to find the "value of nature". Nature is the source of much value to us every day, and yet it mostly bypasses markets, escapes pricing and defies valuation. This lack of valuation is, we are discovering, an underlying cause for the observed degradation of ecosystems and the loss of biodiversity.

Our project on "The Economics of Ecosystems and Biodiversity" is about addressing this second challenge, and making a comprehensive and compelling economic case for conservation of ecosystems and biodiversity.

A DEFECTIVE ECONOMIC COMPASS?

Some readers may be surprised to learn that the example above is as old as economics. It is from Adam Smith's great classic of 1776. So perhaps a third and smaller challenge is for us to understand why it took mankind over 200 years to really come to grips with the first two challenges!

Two and a quarter centuries ago, land was plentiful, energy was not a major factor of production, and the scarce input to production was financial capital. How times have changed. Adam Smith designed his thinking framework for economics in a world in which global capital and trade were measured in millions, not trillions, of dollars. Bill McKibben (2007) identifies the steam engine and "GDP growth" as the two most significant discoveries of the 18th century, both of which improved the well-being of a significant part of humanity. GDP growth created jobs, avoided recessions, and has thus become a preferred yardstick for progress. However, GDP growth does not capture many vital aspects of national wealth and well-being, such as changes in the quality of health, the extent of education, and changes in the quality and quantity of our natural resources.

It can be said that we are trying to navigate uncharted and turbulent waters today with an old and defective economic compass. And this is not just a national accounting problem – it is a problem of metrics which permeates all layers of society, from government to business to the individual, and affects our ability to forge a sustainable economy in harmony with nature.

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY – "TEEB"

In March 2007, the G8+5 environment ministers met in Potsdam. Inspired by the momentum for early action and policy change created by the *Stern Review of the Economics of Climate Change*, they expressed the need to explore a similar project on the economics of the loss of ecosystems and biodiversity. The Minister for the Environment in Germany, Sigmar Gabriel, with the support of the European Commissioner for the Environment, Stavros Dimas, took the lead and accepted the challenge of organizing this study.

The sheer complexity and size of the task was self-evident, and its urgency quite compelling, so I felt both deeply honoured and not a little worried when Commissioner Dimas and Minister Gabriel offered me the position of Study Leader for this task. The science of biodiversity and ecosystems is still evolving, their services to humanity only partially mapped and imperfectly understood, and the economics used to assign monetary values to these sometimes contentious. However, I believed in the vision driving this project, I felt it was crucial and timely that it be done, and so I accepted the assignment happily.

I was reminded of a similar trepidation I had felt when, four years ago, some friends and I launched an ambitious "green accounting" project for India and its states with the aim of providing a practical "sustainability" yardstick for their economies, adjusting classical GDP measures and reflecting large unaccounted externalities such as those involving ecosystems and biodiversity. Most of the results of this project are already published (Green Indian State Trust, 2004-2008), and some have already been used, a rewarding experience from which *inter alia* we learnt the importance of challenging people's expectations, including our own.

As Phase I of TEEB draws to a close, I would like to give due recognition to the overwhelming support and engagement we have received from such a vast number of contributors from all over the world (see Acknowledgements, page 60).

Firstly, I wish to thank all the members of our "core team", who worked tirelessly and it seemed continuously for weeks on end, often taking time off their day jobs to pull together, evaluate, extract and summarize volumes of material that came to us, and who contributed to the writing of this interim report. I wish to thank all those who contributed knowledge and papers on various aspects of the subject; we received over 100 submissions in response to our calls for evidence in September 2007 and March 2008. Our key meeting (Brussels, March 2008) drew 90 participants from almost as many institutions, many of whom wrote in subsequently with information and advice. We outsourced much of the work in Phase I to a set of distinguished research institutions, all of whom delivered excellent meta-studies and papers in very short time, and for this we thank the teams at FEEM, IEEP, Alterra, GHK, ECOLOGIC and IVM. Furthermore, colleagues at EEA, IUCN and UFZ provided valuable support in writing and editing. I thank especially our distinguished Advisory Board, both for agreeing to be involved and for taking time off their very busy schedules to advise me on this project. And finally, our thanks to the governments and institutions that supported this project, the G8+5, UNEP, IUCN, EEA, and especially the teams at our hosts and sponsors the DG Environment, EU Commission and BMU, Germany.

HIGHLIGHTS OF PHASE I

There is a new model evolving here: it is collegiate, collaborative and global. We have every hope and expectation that this will continue into Phase II, and indeed, we intend to increase and broaden our base of contributors, contractors, partners and advisers.

There were five main deliverables from Phase I of TEEB, and short summaries of these are given in the Annex to this interim report. These meta-studies and papers have collectively given us a firm foundation of information and analysis from which to launch Phase II.

Here, I would like to highlight three important aspects of our preliminary work in Phase I and our direction for Phase II.

The first is that we find poverty and the loss of ecosystems and biodiversity to be inextricably intertwined. We explored who were the immediate beneficiaries of many of the services of ecosystems and biodiversity, and the answer is that it is mostly the poor. The livelihoods most affected are subsistence farming, animal husbandry, fishing and informal forestry – most of the world's poor are dependent on them. This realization (see Chapter 3, "GDP of the poor") needs further research for global substantiatiation and we intend to carry it out in Phase II. Annual natural capital losses are typically estimated at an unimpressive few percentage points of GDP. If, however, we re-express these in human terms, based on the principle of equity and our knowledge of where nature's benefits flow, then the argument for reducing such losses gains considerable strength.

This is about the right of the world's poor to livelihood flows from nature which comprise half of their welfare or more, and which they would find it impossible to replace. We shall also argue that most of the Millennium Development Goals today are in fact hostage to this very basic issue.

The second issue is of ethics – risks, uncertainty, and discounting the future, issues which have also been raised in the *Stern Review*. In most of the valuation studies we examined, discount rates used were in the range 3-5% and higher. Note that a 4% discount rate means that we value a natural service to our own grandchildren (50 years hence) at one-seventh the utility we derive from it, a difficult ethical standpoint to defend. In Phase II we shall address this issue by applying a discrete range of discount rates representing different ethical standpoints.

Finally, and most important perhaps, we are convinced that every aspect of the economics of ecosystems and biodiversity that we examine and represent here, and in Phase II, must be sharply focused on the end-user – be it the policy maker, the local administrator, the corporation or the citizen.

OUR AMBITIONS FOR PHASE II

Phase II of TEEB sets out to conclude our scoping and exploratory work during Phase I and achieve four important objectives. These are to:

- firm up and publish a "science and economics framework" which can help frame valuation exercises for most of Earth's ecosystems, including in its scope all material values across the most significant biomes;
- further evaluate and publish "recommended valuation methodology", including biomes (e.g. oceans) and some values (e.g. option values and bequest values) which have not been investigated in depth in Phase I;
- engage all key "end-users" of our valuation work, early and comprehensively, to ensure that our output is as focused as possible on their needs, and "user-friendly" in terms of its organization, accessibility, practicability and, overall, its usefulness.
- further evaluate and publish a policy toolkit for policy makers and administrators which supports policy reform and environmental impact assessment with the help of sound economics, in order to foster sustainable development and better conservation of ecosystems and biodiversity

I have been a banker and a markets professional for 25 years. Two tenets that I learnt early and which have always stood me in good stead are that “the seeds of trouble are sown in good times”, and that “you cannot manage what you do not measure”. No matter how challenging, if we truly want to manage our ecological security, we must measure ecosystems and biodiversity – scientifically as well as economically. The economic compass that we use today was a success when it was created, but it needs to be improved or replaced. I invite you to look, once again, at the cover of this interim report: it is no coincidence that our title and the images are tilted. We need that new compass in place, urgently.

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EXECUTIVE SUMMARY

Nature provides human society with a vast diversity of benefits such as food, fibres, clean water, healthy soil and carbon capture and many more. Though our well-being is totally dependent upon the continued flow of these "ecosystem services", they are predominantly public goods with no markets and no prices, so are rarely detected by our current economic compass. As a result, biodiversity is declining, our ecosystems are being continuously degraded and we, in turn, are suffering the consequences.

Taking inspiration from ideas developed in the Millennium Ecosystem Assessment, our initiative, The Economics of Ecosystems and Biodiversity (TEEB), aims to promote a better understanding of the true economic value of ecosystem services and to offer economic tools that take proper account of this value. We are confident that the results of our work will contribute to more effective policies for biodiversity protection and for achieving the objectives of the Convention on Biological Diversity.

TEEB is in two phases and this interim report summarizes the results of Phase I. It demonstrates the huge significance of ecosystems and biodiversity and the threats to human welfare if no action is taken to reverse current damage and losses. Phase II will expand on this and show how to use this knowledge to design the right tools and policies.

PHASE I

The world has already lost much of its biodiversity. Recent pressure on commodity and food prices shows the consequences of this loss to society. Urgent remedial action is essential because species loss and ecosystem degradation are inextricably linked to human well-being. Economic growth and the conversion of natural ecosystems to agricultural production will, of course, continue. We cannot – and should not – put a brake on the legitimate aspirations of countries and individuals for economic development. However, it is essential to ensure that such development takes proper account of the real value of natural ecosystems. This is central to both economic and environmental management.

In Chapters 1 and 2 of this report we describe how, if we do not adopt the right policies, the current decline in biodiversity and the related loss of ecosystem services will continue and in some cases even accelerate – some ecosystems are likely to be damaged beyond repair. Findings on the cost of inaction suggest that, with a "business-as-usual" scenario, by 2050 we will be faced with serious consequences:

- 11% of the natural areas remaining in 2000 could be lost, chiefly as a result of conversion for agriculture, the expansion of infrastructure, and climate change;
- almost 40% of the land currently under low-impact forms of agriculture could be converted to intensive agricultural use, with further biodiversity losses;
- 60% of coral reefs could be lost – even by 2030 – through fishing, pollution, diseases, invasive alien species and coral bleaching due to climate change.

Current trends on land and in the oceans demonstrate the severe dangers that biodiversity loss poses to human health and welfare. Climate change is exacerbating this problem. And again, as with climate change, it is the world's poor who are most at risk from the continuing loss of biodiversity. They are the ones most reliant on the ecosystem services which are being undermined by flawed economic analysis and policy mistakes.

The ultimate aim of our work is to provide policy makers with the tools they need to incorporate the true value of ecosystem services into their decisions. So in Chapter 3 – since ecosystem economics is still a developing discipline – we describe the key challenges in developing and applying suitable methodologies. In particular, there are ethical choices to be made between present and future generations and between peoples in different parts of the world and at different stages of development. Without taking these aspects into account, the Millennium Development Goals cannot be achieved.

Some promising policies are already being tried out. In Chapter 4 we describe several that are already working in some countries and could be scaled up and/or replicated elsewhere. These examples come from many different fields, but they convey some common messages for developing the economics of ecosystems and biodiversity:

- rethink today's subsidies to reflect tomorrow's priorities;
- reward currently unrecognized ecosystem services and make sure that the costs of ecosystem damage are accounted for, by creating new markets and promoting appropriate policy instruments;
- share the benefits of conservation;
- measure the costs and benefits of ecosystem services.

PHASE II

The economic approach we will be working on in Phase II will be spatially specific and will build on our knowledge of how ecosystems function and deliver services. We will also examine how ecosystems and their associated services are likely to respond to particular policy actions. It will be essential to take account of the ethical issues and equity, and of the risks and uncertainty inherent in natural processes and human behaviour.

Most biodiversity and ecosystem benefits are public goods that have no price. There are different approaches for solving this problem. Notably, we can adopt policies that reward preservation of the flow of these public goods, or we can encourage "compliance markets" which attach tradable values to the supply or use of these services. One example is payments for ecosystem services (PES). These can create demand so as to correct the imbalances which harm biodiversity and impede sustainable development. Phase II will examine the investment case for PES, but also for other new and innovative instruments.

New markets are already forming which support and reward biodiversity and ecosystem services. To be successful, they need the appropriate institutional infrastructure, incentives, financing and governance: in short, investment and resources. In the past, the state was often considered solely responsible for managing ecosystems. Now it is clear that markets can also play their part – often without drawing on public money.

The fundamental requirement is to develop an economic yardstick that is more effective than GDP for assessing the performance of an economy. National accounting systems need to be more inclusive in order to measure the significant human welfare benefits that ecosystems and biodiversity provide. By no longer ignoring these benefits, such systems would help policy makers adopt the right measures and design appropriate financing mechanisms for conservation.

Countries, companies and individuals need to understand the real costs of using the Earth's natural capital and the consequences that policies and actions, individual or collective, have on the resilience and sustainability of natural ecosystems. We believe that policies which better reflect the true value of biodiversity and natural ecosystems will contribute to sustainable development by helping to secure the delivery of ecosystem goods and services, particularly food and water, in a transparent and socially equitable way. This will not only protect biodiversity, ecosystems and the associated ecosystem services, but will also improve the well-being of our present generation and the generations to come.

If we are to achieve our highly ambitious goals we will need to draw on the knowledge, skills, and talent of countries, international bodies, academia, business and civil society from around the world. We look forward to working together openly, flexibly and constructively and to seeing further substantive progress in 2009 and 2010.

1 BIODIVERSITY AND ECOSYSTEMS TODAY

"Global warming may dominate headlines today.

Ecosystem degradation will do so tomorrow."

Corporate Ecosystems Services Review, WRI et al. March 2008

Rewarding forest conservation
The leaders of the communities in Latin America's forested areas want a consensus on the economic compensation for environmental services that they give to the planet by helping conserve millions of hectares of native woodland in the tropics. And it seems that they are being heard: Brazil's government has just decided to pay residents of the Amazon money and credits for their "eco-services" in helping to preserve the country's vast forested area.

Terra Daily 6 April 2008

Emerging markets for environmental services
A private equity firm recently bought the rights to environmental services generated by a 370,000 hectare rainforest reserve in Guyana, recognizing that such services – water storage, biodiversity maintenance, and rainfall regulation – will eventually be worth something on international markets. Revenues will be shared with 80% going to the local community. The reserve supports 7,000 people and locks up some 120 million tonnes of carbon. President Jagdeo of Guyana has cited it as a potential model for payments for all such services.

www.iNSnet.org 4 April 2008

Ecosystem collapse
On 20 February 2008, between 500 and 700 tonnes of fish were reported dead in fish cages in the marine waters of Amvrakikos, Greece (Eleftherotypia 20 February 2008). Scientists have suggested it is likely that the reduction of freshwater inflow into the gulf could be the cause of these incidents. The cost to restore some of the ecosystem functions in the lagoons is estimated at EUR 7 million.

EC DG ENV 2008

Environmental refugees increase
Environmental refugees already number some 25 million, and it is estimated that by 2020, some 60 million people will move from desertified areas in Sub-Saharan Africa towards Northern Africa and Europe. But this south-north migration is nothing, compared to internal migrations within Africa itself. Most internal refugees settle in bloated megacities, a trend that – given the scarce water resources – is regarded as a potential disaster. Trapped in a deteriorating environment without access to freshwater and plagued by rising food prices, refugees and locals alike may be prone to poverty, disease, and unrest.

http://knowledge.allianz.com 19 March 2008

These news bulletins above give us a glimpse of an emerging new nexus: the connection between nature, its preservation and destruction, human welfare, and finally, money. Historically, nature's role as the nurturer of human society was accepted as a given, and the "maternal" image of nature abounds in rituals, epics and beliefs across all societies and times. Over the last half century however, the intricate relationship between human wealth and welfare and biodiversity, ecosystems and their services is increasingly being understood in ecological and economic terms. Our knowledge, of the many dimensions of this relationship is improving fast. At the same time, we are recognizing increasing natural losses – worsening environments, declining species.

Many high-profile species such as pandas, rhinos and tigers face extinction, while rainforests, wetlands, coral reefs and other ecosystems are under huge pressure from human activity. Natural disasters such as floods, droughts and landslides are today almost commonplace, while food and water shortages have recently been commanding world attention.

While there is some understanding that these many phenomena are in some way connected, there is at the same time an expectation that "normal service" will soon be resumed. There seems to be little appreciation of the many dimensions of biodiversity loss, or the connections between biodiversity loss, climate change and economic development. Species loss and ecosystem degradation are inextricably linked to human well-being, and unless we take urgent remedial action, "normal service" – in the sense of being able to enjoy the benefits that our environment affords us – may never be resumed.

Humanity receives countless benefits from the natural environment in the form of goods and services (generally grouped under the collective title of ecosystem services) such as food, wood, clean water, energy, protection from floods and soil erosion (see Box 1.1). Natural ecosystems are also the source of many life-saving drugs as well as providing sinks for our wastes, including carbon. Human development has also been shaped by the environment, and this interlinkage has strong social, cultural and aesthetic importance. **The well-being of every human population in the world is fundamentally and directly dependent on ecosystem services.**

However, the levels of many of the benefits we derive from the environment have plunged over the past 50 years as biodiversity has fallen dramatically across the globe. Here are some examples:

- In the last 300 years, the global forest area has shrunk by approximately 40%. Forests have completely disappeared in 25 countries, and another 29 countries have lost more than 90% of their forest cover. The decline continues (FAO 2001; 2006).

- Since 1900, the world has lost about 50% of its wetlands. While much of this occurred in northern countries during the first 50 years of the 20th century, there has been increasing pressure since the 1950s for conversion of tropical and sub-tropical wetlands to alternative land use (Moser et al. 1996).

- Some 30% of coral reefs – which frequently have even higher levels of biodiversity than tropical forests – have been seriously damaged through fishing, pollution, disease and coral bleaching (Wilkinson 2004).

- In the past two decades, 35% of mangroves have disappeared. Some countries have lost up to 80% through conversion for aquaculture, overexploitation and storms (Millennium Ecosystem Assessment 2005a).

- The human-caused (anthropogenic) rate of species extinction is estimated to be 1,000 times more rapid than the "natural" rate of extinction typical of Earth's long-term history (Millennium Ecosystem Assessment 2005b).

Box 1.1: Key terms

- **An ecosystem is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Examples of ecosystems include deserts, coral reefs, wetlands, rainforests, boreal forests, grass-lands, urban parks and cultivated farmlands. Ecosystems can be relatively undisturbed by people, such as virgin rainforests, or can be modified by human activity.**

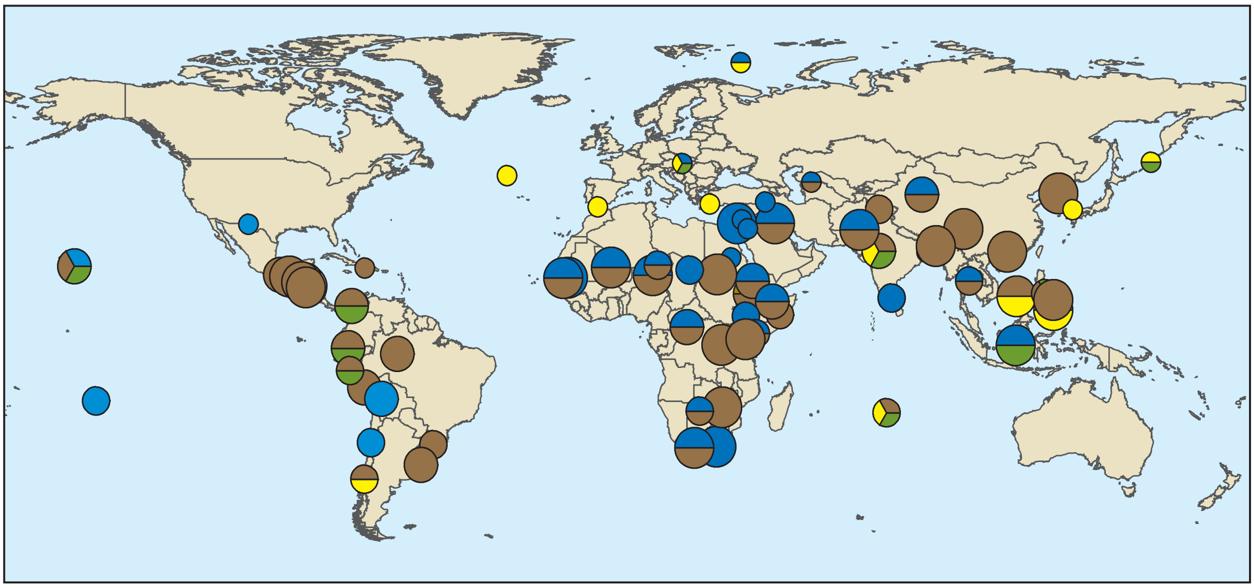
- **Ecosystem services are the benefits that people obtain from ecosystems. Examples include food, freshwater, timber, climate regulation, protection from natural hazards, erosion control, pharma-ceutical ingredients and recreation.**

- **Biodiversity is the quantity and variability among living organisms within species (genetic diversity), between species and between ecosystems. Biodiversity is not itself an ecosystem service but underpins the supply of services. The value placed on biodiversity for its own sake is captured under the cultural ecosystem service called "ethical values".**

Apr 21st 2005 | PANAMA CITY
From: The Economist print edition

The effect of trends such as these is that approximately 60% of the Earth's ecosystem services that have been examined have been degraded in the last 50 years, with human impacts being the root cause (Millennium Ecosystem Assessment 2005c). Further declines are projected over the coming decades because of factors such as population growth, changing land use, economic expansion and global climate change. Leading international economic organizations such as the World Bank and the Organisation for Economic Co-operation and Development (OECD) confirm these worrying predictions. The OECD has described a highly daunting combination of challenges facing humanity: tackling climate change, halting biodiversity loss, ensuring clean water and adequate

Map 1.1: Environmental conflicts



Conflict intensity

- Diplomatic crisis
- Protests (partly violent)
- Use of violence (national scope)
- Systematic/collective violence

Conflict cause

- Water
- Land/soil
- Fish
- Biodiversity

Source: WBGU, 2008

sanitation, and reducing the human health impacts of environmental degradation (OECD 2008).

The pressures have intensified even in the short time since the publication of the Millennium Ecosystem Assessments in 2005. In 2007, more people were living in urban than rural areas for the first time in human history. During 2007 and 2008, the push to develop biofuels resulted in massive changes in land use and a steep increase in the price of some staple food crops. Continuing high rates of economic growth in some of the large developing economies have resulted in demand outstripping supply for several commodities, putting even greater pressure on natural systems. Recent evidence of climate change suggests much faster and deeper impacts than previously predicted, including the risk of human conflicts caused by competition for biodiversity resources and ecosystem services (WBGU 2008).

Such trends may change our relationship with nature but not our reliance on it. Natural resources, and the ecosystems that provide them, underpin our economic activity, our quality of life and our social cohesion. But the way we organize our economies does not give sufficient recognition to the dependent nature of this relationship – **there are no economies without environments, but there are environments without economies.**

There have been many attempts to fill this gap by putting some kind of monetary value on ecosystem services. Such approaches can be helpful, but above all we need to regain a sense of humility about the natural world. As traditional peoples have long understood, we must ultimately answer to nature, for the simple reason that nature has limits and rules of its own.

We are consuming the world's biodiversity and ecosystems at an unsustainable rate and this is already starting to have serious socio-economic impacts. If we are to find solutions to the problems we face, we need to understand what is happening to biodiversity and ecosystems and how these changes affect the goods and services they provide. We then need to look at the way we can use economic tools to ensure that future generations can continue to enjoy the benefits of these goods and services.

This is a highly complex challenge, but one which must be met. However, lessons from the last 100 years demonstrate that mankind has usually acted too little and too late in face of similar threats – asbestos, CFCs, acid rain, declining fisheries, BSE, contamination of the Great Lakes and, most recently and dramatically, climate change. Assigning just 1% of global GDP up to 2030 can achieve significant improvements in air and water quality and human health, and ensure progress toward climate targets. As the OECD has observed: "You can call it the cost of insurance" (OECD 2008). With the benefit of hindsight, we recognize the mistakes that we have made in the past and we can learn from them (EEA 2001).

The loss of biodiversity and ecosystems is a threat to the functioning of our planet, our economy and human society. We believe it is essential to start tackling this problem as soon as possible. We do not have all the answers, but in the remainder of this document we will describe a framework for action that we hope will attract wide support.

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2 BIODIVERSITY, ECOSYSTEMS AND HUMAN WELFARE

"No place is immune, neither the arid Sahel of Africa nor the grain-exporting regions of Australia nor the drought-prone Southwest of the US. To fight it [climate change], the UN family … has begun tapping into a pool of global resources – scientific and engineering expertise, corporate engagement and civic leadership. We have begun to appreciate more fully how the world's dazzling know-how can solve the seemingly unsolvable when we view our problems from the right perspective."

Ban Ki-moon, UN Secretary-General 2008

The UN Secretary-General's resolute optimism with regard to tackling climate change could also be taken as an appropriate rallying call for addressing the problem of biodiversity loss. It will indeed take a global response and a concerted effort from all nations and across all sections of society if we are to achieve our goal.

Today's global consumption and production patterns are underpinned by ecosystems around the world. Many different types of policy can affect the resilience of natural as well as human-modified ecosystems. From transport to energy, agriculture to cultural well-being, policies and actions can have many unintended consequences. As demonstrated by the Millennium Ecosystem Assessment (2005a), the impacts of cumulative pressures on ecosystems may not be felt for many years, until some tipping points are reached leading to rapid non-linear changes. We begin this chapter with selected examples that illustrate the wide range of effects, from food to health. Then we set out some common themes, especially the disproportionate impact on the poor.

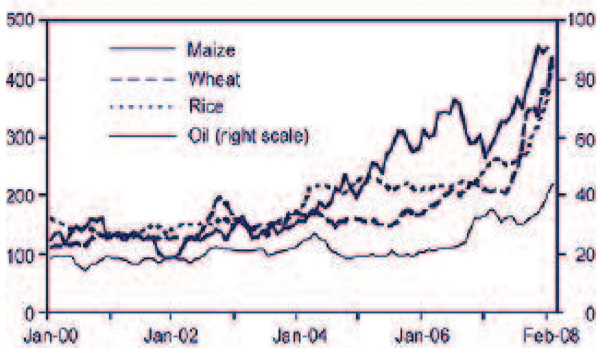
This chapter shows that the implications of ecosystem degradation can be far-reaching, for example the threat to healthcare from the loss of plant species. The result, as this chapter concludes, is that business-as-usual is not an option, even in the short-term.

PRESSURES ON BIODIVERSITY WILL CONTINUE AND HUMAN WELL-BEING WILL BE AFFECTED

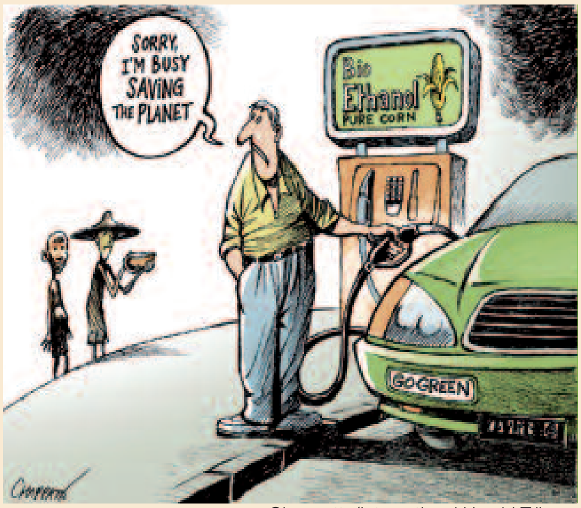
FOOD IS NEWS ON LAND.....

Rising food prices have provoked protests in many countries. In February 2007, tens of thousands of people marched through the streets of Mexico City, demonstrating against a 400% increase in the cost of corn used to make tortillas –

Figure 2.1: World commodity prices, January 2000-February 2008 (US$/tonne)



Source: FAO International Commodity Prices database, 2008; IMF World Economic Outlook database, 2007.



Chappatte/International Herald Tribune

Box 2.1: Biofuels generate much debate

Bioenergy can play an important role in combating climate change, specifically if biomass is used for heat and electricity generation. However, biofuels also are another source of competition for scarce land, and the scale of potential land conversion for agro-fuels is extraordinary. The International Monetary Fund reports that "although biofuels still account for only 1.5% of the global liquid fuels supply, they accounted for almost half of the increase in consumption of major food crops in 2006-2007, mostly because of corn-based ethanol produced in the US". Reports indicate that this pattern could be replicated elsewhere in the world.

IMF April 2008

blamed on increased demand for biofuels in the United States of America. In Asia, many governments had to intervene to ease rocketing rice prices and to manage supplies, while the Philippines also distributed food aid to affected people in rural areas.

There are many causes for the increase in food prices. They include rising demand for food and especially meat (which requires more land per calorie), the rising price of energy (which is an important input) and increasing demand for biofuels.

In 2007, the food price index calculated by the Food and Agriculture Organization of the United Nations (FAO) rose by nearly 40%, compared with 9% the previous year (FAO 2008). In the first months of 2008 prices again increased drastically. Nearly every agricultural commodity is part of this rising price trend (FAO 2008). As demand for basic commodities increases, this raises the pressure to convert natural ecosystems into farmland and to increase the intensity of production from already converted land. Already, the shift toward higher meat consumption is one of the most important causes of deforestation worldwide (FAO 2006).

There is no sign that this pressure for conversion from natural ecosystems towards arable land will abate. Demand for food is set to increase as populations grow and their consumption shifts towards more meat. Supply cannot keep pace as yields are growing only slowly. On top of this, scientists of the Intergovernmental Panel on Climate Change (IPCC) predict in their 2007 report that even slight global warming would decrease agricultural productivity in tropical and subtropical countries (IPCC 2007).

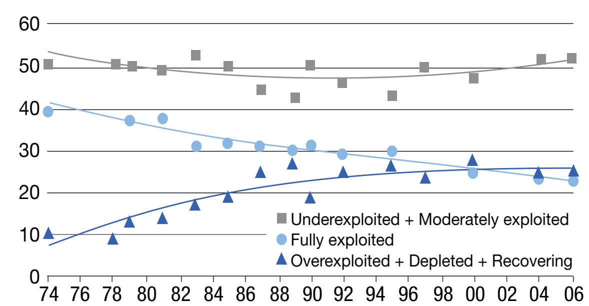
.....AND AT SEA

More than a billion people rely on fisheries as their main or sole source of animal protein, especially in developing countries (Millennium Ecosystem Assessment 2005a). But half of wild marine fisheries are fully exploited, with a further quarter already overexploited (FAO 2007). We have been "fishing down the food web". As stocks of high-trophic, often larger species are depleted, fishermen have targeted lower-trophic, often smaller species. The smaller fish are increasingly used as fish meal and fish oil for aquaculture and to feed poultry and pigs. Aquaculture, which includes mobile open-sea cages (e.g. for red tuna) is growing quickly, particularly in China and the Mediterranean, and contributed 27% of world fish production in 2000 (Millennium Ecosystem Assessment 2005a). Aquaculture is, however, extremely dependent on marine fisheries for its inputs and, looked at from a global perspective, it may not be reducing our overall dependency on wild marine fisheries.

"Fishing down the food web" leads to diverse impacts on the biodiversity of the oceans. The blooms of jellyfish that have increased rapidly worldwide in the last decade are believed to result in part from this situation. Jellyfish have replaced fish as the dominant planktivores in several areas, and there is some concern that these community shifts may not be easily

Figure 2.2: Global trends in the state of marine stocks since 1974

Percentage of stocks assessed



Source: FAO 2006

European Community

reversible, since the jellyfish also eat the eggs of their fish competitors (Duffy 2007).

This loss of biodiversity could have disastrous effects on the supply of seafood to the human population and on the economy. There is increasing evidence that species diversity is important for marine fisheries, both in the short term, by increasing productivity, and in the long term, by increasing resilience, while genetic diversity is important particularly for the latter. A 2006 study (Worm et al. 2006) concluded that all of the world's commercial fisheries are likely to have collapsed in less than 50 years unless current trends are reversed. It found that low diversity is associated with lower fishery productivity, more frequent "collapses", and a lower tendency to recover after overfishing than naturally species-rich systems.

The security value of biodiversity can be compared with financial markets. A diverse portfolio of species stocks, as with business stocks, can provide a buffer against fluctuations in the environment (or market) that cause declines in individual stocks. This stabilizing effect of a "biodiverse" portfolio is likely to be especially important as environmental change accelerates with global warming and other human impacts.

WATER SUPPLY INCREASINGLY AT RISK

There is also growing pressure on water resources – both the supply of water and its quality. Many parts of the world already live with water stress. The risk of water wars was a major theme at the 2008 World Economic Forum in Davos. The United Nations believes there is enough to go round – but only if we keep it clean, use it wisely and share it fairly.

In Asia, the water vital for the irrigation of the grain crops that feed China and India is at risk of drying up because of climate change. Global warming melts the glaciers that feed Asia's biggest rivers in the dry season – precisely the period when water is needed most to irrigate the crops on which hundreds of millions of people depend. In this example, **climate**

Box 2.2: Coral reefs

Coral reefs are the most biodiversity-rich ecosystems (in species per unit area) in the world, more diverse even than tropical forests. Their health and resilience are in decline because of overfishing, pollution, disease and climate change.

Caribbean coral reefs have been reduced by 80% in three decades. As a direct result, revenues from dive tourism (close to 20% of total tourism revenue) have declined and are predicted to lose up to US$ 300 million per year. That is more than twice as much as losses in the heavily impacted fisheries sector (UNEP February 2008).

The underlying explanation for this situation is that in 1983, following several centuries of overfishing of herbivores, there was a sudden switch from coral to algal domination of Jamaican reef systems. This left the control of algal cover almost entirely to a single species of sea urchin, whose populations collapsed when exposed to a species-specific pathogen. When the sea urchin population collapsed, the reefs shifted (apparently irreversibly) to a new state with little capacity to support fisheries. This is an excellent example of the insurance value in biologically diverse ecosystems. The reduction in herbivore diversity had no immediate effect until the sea urchin population plummeted, illustrating how vulnerable the system had become due to its dependence on a single species.

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change could accentuate the problems of chronic water shortage and drive the ecosystem service that provides a reliable supply of clean water beyond breaking point.

In many areas, ecosystems provide vital regulating functions. Forests and wetlands can play an important role in determining levels of rainfall (at a regional and local level), the ability of land to absorb or retain that water and its quality when used. In other words, ecosystems play a part in determining whether we have droughts, floods and water fit to drink. The value of this role is often forgotten until it is lost.

OUR HEALTH IS AT STAKE

People have known the medicinal value of certain plants for thousands of years and biodiversity has helped our understanding of the human body. So ecosystems provide huge health benefits, and thus economic benefits. The corollary is that losing biodiversity incurs potentially huge costs, and our knowledge of these is growing (Conseil Scientifique du Patrimoine Naturel et de la Biodiversité – in press).

There are significant direct links between biodiversity and modern healthcare (Newman and Cragg 2007):

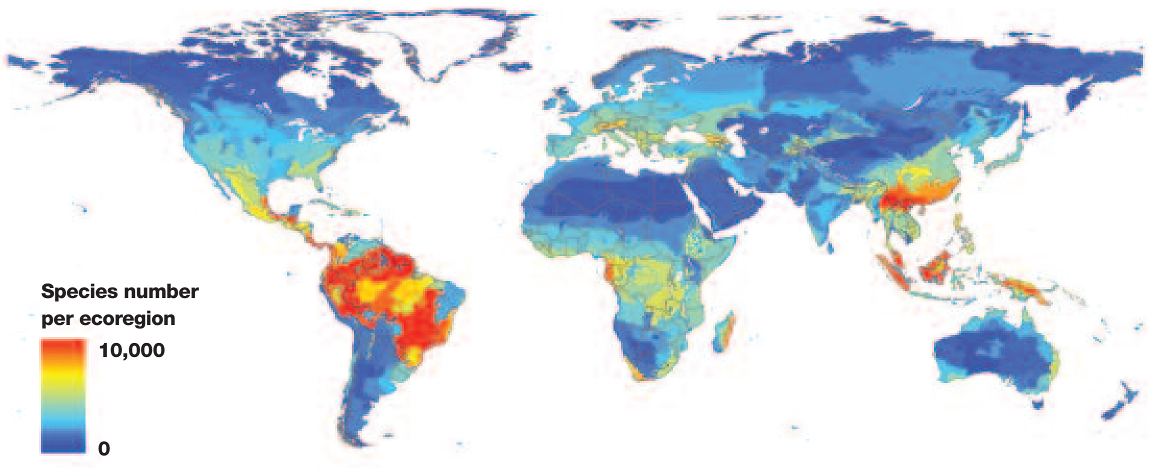
- Approximately half of synthetic drugs have a natural origin, including 10 of the 25 highest selling drugs in the United States of America.
- Of all the anti-cancer drugs available, 42% are natural and 34% semi-natural.
- In China, over 5,000 of the 30,000 recorded higher plant species are used for therapeutic purposes.
- Three quarters of the world's population depend on natural traditional remedies.
- The turnover for drugs derived from genetic resources was between US$ 75 billion and US$ 150 billion in the United States of America in 1997.
- The gingko tree led to the discovery of substances which are highly effective against cardiovascular diseases, accounting for a turnover of US$ 360 million per year.

Despite the enormous health benefits, plants are disappearing fast and will continue to do so unless urgent action is taken. The *2007 IUCN Red List of Threatened Species* identified a significant increase in species under threat during this decade. It estimates that 70% of the world's plants are in jeopardy (IUCN 2008).

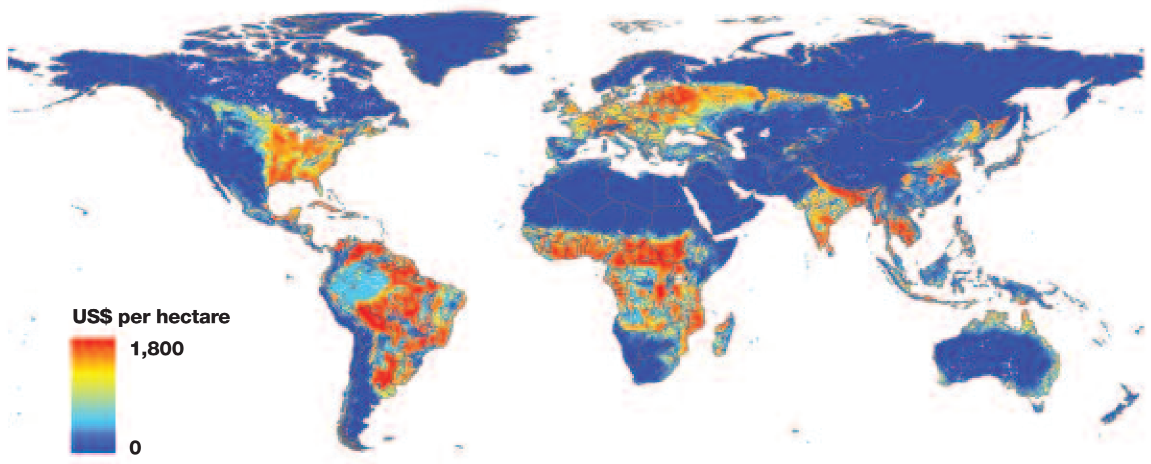
A recent global study reveals that **hundreds of medicinal plant species, whose naturally occurring chemicals make up the basis of over 50% of all prescription drugs, are threatened with extinction**. This prompted experts to call for action to "secure the future of global healthcare". (Hawkins 2008).

The biodiversity-healthcare relationship also has a strong distributional equity dimension. There is often a mismatch between the regions where benefits are produced, where their value is enjoyed, and where the opportunity costs for their conservation are borne. So the plant species that are the sources of many new drugs are likely to be found in poorer tropical regions of the world (see Map 2.1). The people that benefit are more likely to be found in rich countries where the resulting drugs are more readily available and affordable. People in these countries therefore have a great incentive to conserve natural habitats in biodiversity-rich parts of the world. However, such conservation has costs for local people in these parts, in particular the opportunity costs such as the loss in potential agriculture returns (see Map 2.2) of not converting such habitats. Transferring some of the rich world benefits back to local people could be one approach to improving

Map 2.1: Plant species per ecoregion (Kier et al. 2005, J. Biogeog. 32:1107)



Map 2.2: Agricultural returns (Strassburg et al. 2008, based on data from Naidoo & Iwamura. 2007. Biol. Conserv. 140: 40)



incentives to conserve those natural habitats and species locally that clearly have wider benefits globally.

It is clear that if we undermine the natural functions that hold this planet together, we may be creating conditions that will make life increasingly difficult for generations to come – and impossible for those already on the margins of survival.

GROWTH AND DEVELOPMENT

Population growth, increasing wealth and changing consumption patterns underlie many of the trends we have described. Unsustainable resource use has been evident in the developed world for many years. The ecological footprints of Europe, the United States of America and Japan are much higher than those of developing countries. And the emerging economies are catching up. India and China both have ecological footprints twice the size of their "biocapacities" (Goldman Sachs 2007) – the extent to which their ecosystems can generate a sustainable supply of renewable resources. Brazil, on the other hand, has one of the world's highest "biocapacities", nearly five times as large as its ecological footprint, yet this is declining as a result of deforestation (Goldman Sachs 2007).

Under current practices, meeting the food needs of growing and increasingly affluent populations will further threaten biodiversity and ecosystem services. Based on population projections alone, 50% more food than is currently produced will be required to feed the global population by 2050 (United Nations Department of Economic and Social Affairs/Population Division 2008). Irrigated crop production will need to increase by 80% by 2030 to match demand.

Already, 35% of the Earth's surface has been converted for agriculture, limiting scope for the future productivity of natural systems (Millennium Ecosystem Assessment 2005b). The livestock sector already represents the world's single largest human use of land. Grazing land covers 26% of the Earth's surface, while animal feed crops account for about a third of arable land (FAO 2006). Extending agricultural production will have consequences for biodiversity and ecosystem services as more land is converted for food production. The expanding livestock sector will be in direct competition with humans for land, water and other natural resources. Livestock production is the largest sectoral source of water pollutants. It is also a major factor in rising deforestation: 70% of land in the Amazon that was previously forested is now used as pasture, and livestock feed crops cover a large part of the remainder (FAO 2006).

CLIMATE CHANGE AND BIODIVERSITY

Climate change is linked to many of the issues we have presented in this chapter. The El Niño-La Niña cycle in the Pacific Ocean is one prominent example of the vulnerability of biodiversity to climate. A small rise in the sea surface temperature in 1976 and 1998 led to a series of worldwide phenomena, which resulted in 1998 being characterized as "the year the world caught fire". Permanent damage includes (US Department of Commerce 2008):

- burned forests that will not recover within any meaningful human timescale;
- a rise in the temperature of surface waters of the central western Pacific Ocean from an average of 19°C to 25°C;
- shifts toward heat-tolerant species living inside corals;
- a northward shift in the jet stream.

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These types of complex phenomena show us how vulnerable we are to tipping points beyond those linked directly to increasing temperatures and carbon dioxide levels.

Biodiversity losses can also contribute to climate change in many complex ways. There are many examples of how overharvesting or changed land-use patterns have triggered social and economic changes leading to greater reliance on carbon.

Draining peat lands results in carbon losses. But predicted changes to climate could cause accelerated rates of carbon release from the soil, contributing in turn to higher greenhouse gas concentrations in the atmosphere (Bellamy et al. 2005). Under the same climatic conditions, grassland and forests tend to have higher stocks of organic carbon than arable land and are seen as net sinks for carbon. Yet deforestation and intensification of cropland areas are rampant.

To take account of these complexities we will need more than energy-based econometric models. We will need to respond to knowledge about how to adapt and how vulnerabilities might arise from global ecological processes. **This will require a much deeper dialogue than we have seen so far between economists, climate scientists and ecologists.**

IMPACTS ON THE POOR

A striking aspect of the consequences of biodiversity loss is their disproportionate but unrecognized impact on the poor. For instance, if climate change resulted in a drought that halved the income of the poorest of the 28 million Ethiopians, this would barely register on the global balance sheet – world GDP would fall by less than 0.003%.

The distributional challenge is particularly difficult because those who have largely caused the problems – the rich countries – are not going to suffer the most, at least not in the short term.

The evidence is clear. The consequences of biodiversity loss and ecosystem service degradation – from water to food to fish – are not being shared equitably across the world. The areas of richest biodiversity and ecosystem services are in developing countries where they are relied upon by billions of people to meet their basic needs. Yet **subsistence farmers, fishermen, the rural poor and traditional societies face the most serious risks from degradation**. This imbalance is likely to grow. Estimates of the global environmental costs in six major categories, from climate change to overfishing, show that the costs arise overwhelmingly in high- and middle-income countries and are borne by low-income countries (Srinivasan et al. 2007).

Box 2.3: Gender, poverty and biodiversity in Orissa, India

The impact of the loss of biodiversity, often not very visible, has serious implications for poverty reduction and well-being for women as it severely affects the role of women as forest gatherers. Studies in the tribal regions of Orissa and Chattisgarh, states in India which were once heavily forested, have recorded how deforestation has resulted in loss of livelihoods, in women having to walk four times the distance to collect forest produce and in their inability to access medicinal herbs which have been depleted. This loss reduces income, increases drudgery and affects physical health. There is also evidence to show that the relative status of women within the family is higher in well-forested villages, where their contribution to the household income is greater than in villages that lack natural resources.

Sarojini Thakur, Head of Gender Section,
Commonwealth Secretariat, personal communication, May 15th 2008.

Table 2.1: Ecosystem services and the Millennium Development Goals: links and trade-offs

Ecosystem services	**Related MDG**	**Links with targets**	**Conflicting outcome**	**Evaluation**
Provisioning and regulating services	MDG 1: Eradicate extreme poverty and hunger	Steady daily supplies of water, fuelwood and food: these influence the material minimum standard of the lives of the poor, alleviating poverty and hunger	Greater conflicts over water, exploitation of top soil, coastal and marine resources and the resilience of agri-biodiversity could constitute trade-offs	Strong and direct links: Intervention needs to be receptive to ecosystem services, biodiversity and the resilience of cultivated ecosystems
Services from, wetlands and forests	MDG 3: Promote gender equality and empower women	Fuelwood and water: adequate availability and and proximity – would help gender equality by reducing this burden that falls mainly on women (see Box 2.3)	There could be greater extraction of groundwater. The enforcement of land rights for women would, however, ensure the prevention of biodiversity loss to a greater extent	Indirect link
Provisioning (medicinal plants) and regulating services (water)	MDG 5: Improve maternal health	Better availability of clean water and traditional medical services would create enabling conditions (see Box 2.5)		Indirect link
Provisioning and regulating services	MDG 6: Combat HIV/AIDS, malaria and other dieases	This would be facilitated by widening the availability of clean water		Indirect link
Provisioning services	MDG 8: Develop a Global Partnership for Development	Fair and equitable trade practices and a healthy world economic order would reflect the true cost of export/import from the ecosystem services perspective		Indirect link
Provisioning and regulating services	MDG 4: Reduce child mortality	Creating enabling conditions, e.g. through clean water (see Box 2.5)		Indirect link
Provisioning and regulating services	MDG 2: Achieve universal primary education	Provisioning services might be affected by expansion of education-related infrastructure (schools and roads)		Weak or unclear link

The Millennium Development Goals (MDGs) represent the world's ambition to attack poverty. Anecdotal evidence abounds showing that achievement of these goals assumes sound environmental practice and governance. An example that powerfully illustrates this point is that of Haiti (see Box 2.5), where forest degradation and its consequences have jeopardized water availability and agricultural productivity to the point where hunger and poverty elimination (MDG1) has proved impossible, and have severely affected health and child mortality (MDG4, MDG5 and MDG6), to name some of the MDG linkages. In Table 2.1, we map ecosystem services against the MDGs. **The extent of linkage is deep and broad, suggesting that there are significant risks to the achievement of all MDGs, and not just MDG7 about environmental sustainability, if the current pace of ecosystem degradation and biodiversity losses continues unchecked.**

BUSINESS-AS-USUAL IS NOT AN OPTION

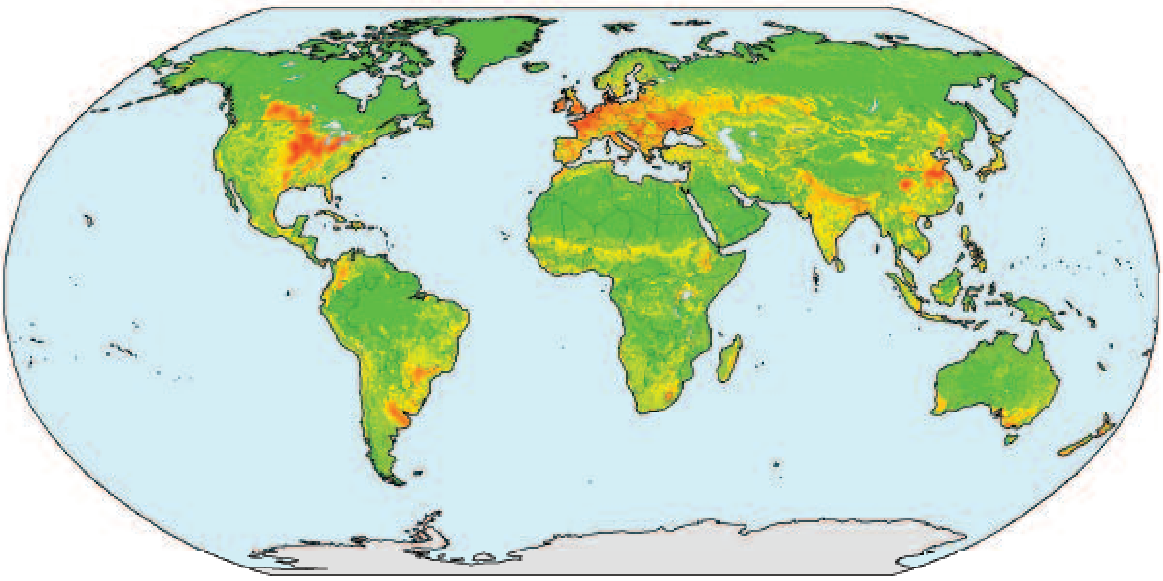
If no major new policy measures are put in place, past trends of biodiversity and ecosystem service loss will continue. In

Box 2.4: The changing use of land and changing services

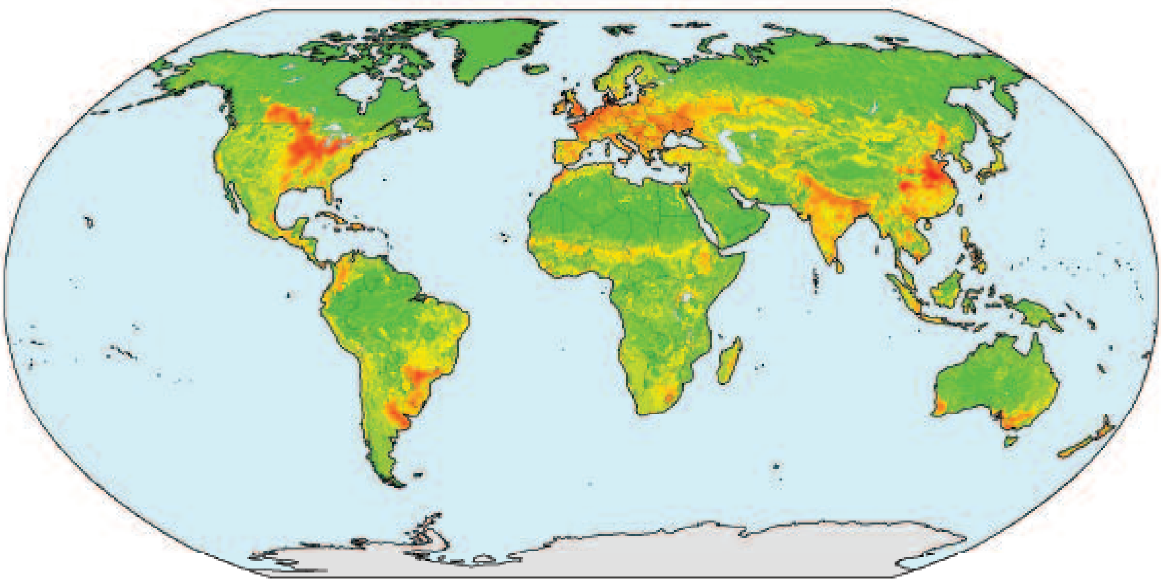
Humans have been causing biodiversity loss for centuries (see maps below). By the year 2000, only about 73% of the original global natural biodiversity was left. The strongest declines have occurred in the temperate and tropical grasslands and forests, where human civilizations first developed (Mc Neill and Mc Neill 2003).

A further 11% of land biodiversity is expected to be lost by 2050, but this figure is an average including desert, tundra and polar regions. In some biomes and regions, projected losses are about 20%. Natural areas will continue to be converted to agricultural land, with the ongoing expansion of infrastructure and increasing effects of climate change being additional major contributors to biodiversity loss. For the world as a whole, the loss of natural areas over the period 2000 to 2050 is projected to be 7.5 million square kilometres or around 750 million hectares, i.e. the size of Australia. These natural ecosystems are expected to undergo human-dominated land-use change in the next few decades. Biodiversity loss in the Cost of Policy

Map 2.3: Mean species abundance 1970 (MNP/OECD 2007)



Map 2.4: Mean species abundance 2000 (MNP/OECD 2007)

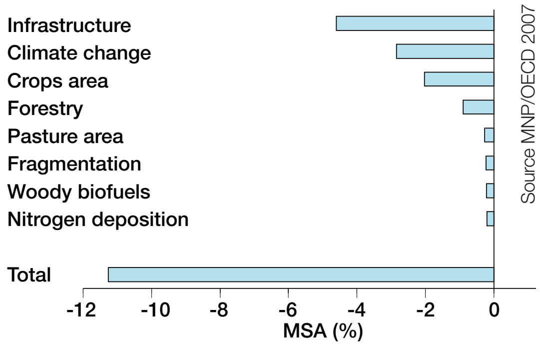


Key to maps 0-10 10-20 20-30 30-40 40-50 50-60 60-70 70-80 80-90 90-100

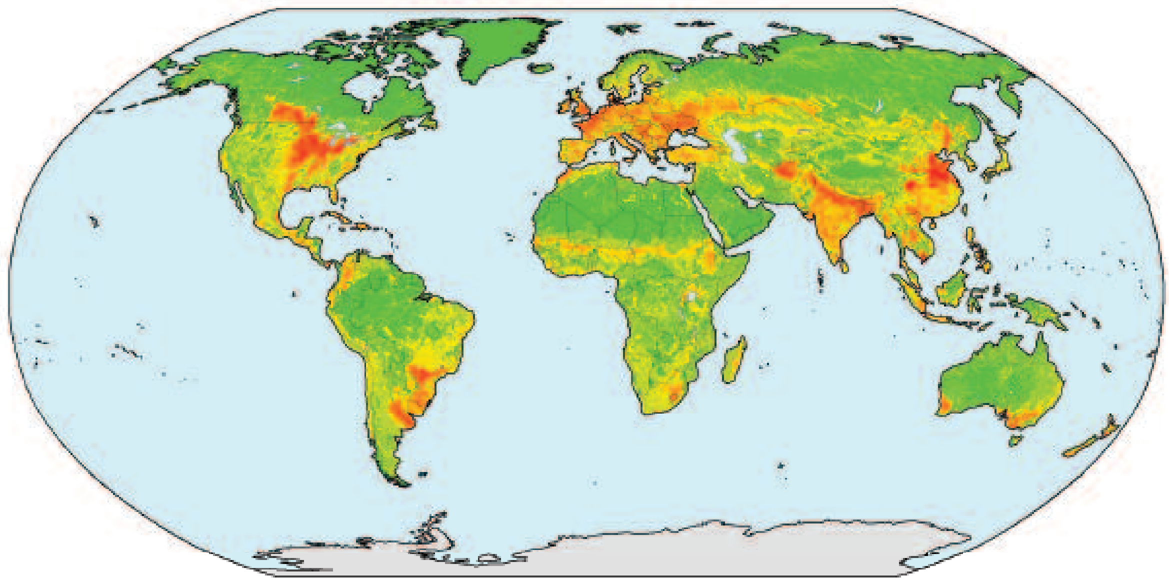
Inaction (COPI) study is measured by the MSA (mean species abundance) indicator, a reliable measure of biodiversity that has been recognized by the Convention on Biological Diversity.

The impact on livelihoods is local and therefore not necessarily reflected in aggregate global numbers. Maps can give a clearer picture and the figures below show the changes in biodiversity based on mean species abundance between 1970, 2000, 2010 and 2050. Major impacts are expected in Africa, India, China and Europe (Braat, ten Brink et al. 2008).

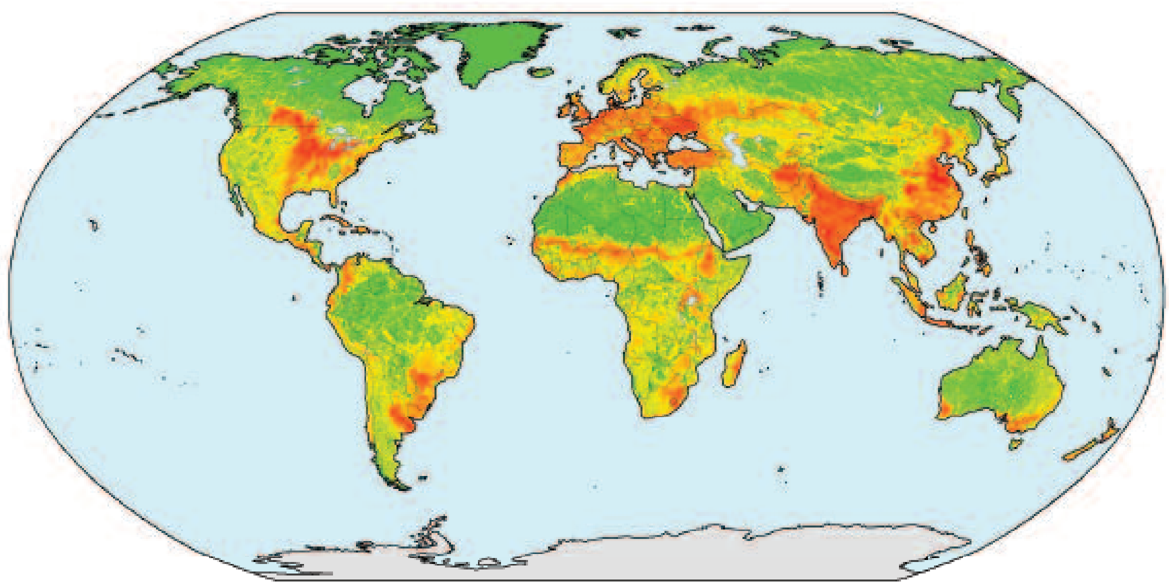
Figure 2.3: Global biodiversity (MSA) loss 2000-2050 and contribution of pressures



Map 2.5 Mean species abundance 2010 (MNP/OECD 2007)



Map 2.6: Mean species abundance 2050 (MNP/OECD 2007)



Key to maps 0-10 10-20 20-30 30-40 40-50 50-60 60-70 70-80 80-90 90-100

Box 2.5: Vicious cycle of poverty and environmental degradation: Haiti

Haiti is the poorest country in the Western Hemisphere and one of the most environmentally degraded. Over 60% of its income comes as aid from the USA and other countries, and 65% of its people survive on less than $1 a day. Almost all of the country was originally forested but now there is less than 3% cover left. As a consequence, from 1950-1990, the amount of arable land fell by more than two fifths due to soil erosion. At the same time deforestation has diminished evaporation back to the atmosphere over Haiti, and total rainfall in many locations has fallen by as much as 40%, reducing stream flow and irrigation capacity. The Avezac Irrigation System supports only half of the initially planned 9,500 acres (3,845 hectares). When the rains do come, hillsides no longer efficiently retain or filter water. Due to deforestation, even moderate rains can produce devastating floods. Ground and stream waters are laden with sediment and pollution which has degraded estuary and coastal ecosystems. As a consequence, nearly 90% of Haitian children are chronically infected with intestinal parasites they acquire from the water they drink. Due to flooding, Haiti has lost half of its hydropower potential since sediment clogged the Peligre Dam.

Haiti is a stark example of the "vicious circle" of extreme poverty and environmental degradation. Much of Haiti's poverty and human suffering derives from the loss of its forests, and extreme poverty is itself one of the root causes of deforestation and a powerful barrier to sustainable forest management. The alleviation of poverty must be a central strategy to restore Haiti's forest and biodiversity.

Amor and Christensen 2008

some cases losses will accelerate. In others the ecosystem will be degraded to such an extent that it will not be possible to repair or recover it. These are some of the likely results of inaction:

- Natural areas will continue to be converted to agricultural land, and will be affected by the expansion of infrastructure and by climate change. By 2050, 7.5 million square kilometres are expected to be lost, or 11% of 2000 levels (see next section) (Braat, ten Brink et al. 2008).

- Land currently under extensive (low-impact) forms of agriculture, which often provides important biodiversity benefits, will be increasingly converted to intensive agricultural use, with further biodiversity losses and with damage to the environment. Almost 40% of land currently under extensive agriculture is expected to be lost by 2050 (Braat, ten Brink et al. 2008).

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- 60% of coral reefs could be lost by 2030 through fishing damage, pollution, disease, invasive alien species and coral bleaching, which is becoming more common with climate change. This risks losing vital breeding grounds as well as valuable sources of revenue to nations (Hughes et al. 2003).

- Valuable mangrove areas are likely to be converted to use for private gain, often to the detriment of local populations. Important breeding grounds will be lost, as will buffers that protect against storms and tsunamis.

- If current levels of fishing continue, there is the risk of collapse of a series of fisheries. The global collapse of most world fisheries is possible by the second half of the century unless there is an effective policy response – and enforcement (Worm et al. 2006).

- As global trade and mobility increase, so do the risks from invasive alien species for food and timber production, infrastructure and health.

Business-as-usual is not an option if we wish to avoid these consequences and to safeguard our natural capital and the well-being of future generations. The cost of insufficient policy action is too great.

Some solutions are already visible, however, and economics could play an important part. Although forests are at risk of conversion to agriculture, grazing lands and biofuel production, they can play a valuable role as carbon sinks and biodiversity vaults, and this capacity could be recognized by a higher market value (see REDD in Chapter 4).

WHAT NEXT?

Managing humanity's desire for food, energy, water, life-saving drugs and raw materials, while minimizing adverse impacts on biodiversity and ecosystem services, is today's leading challenge for society. Maintaining an appropriate balance between competing demands means understanding economic resource flows and tracking the biological capacity needed to sustain these flows and absorb the resulting waste.

Five common threads emerge from this chapter's quick sweep across the many dimensions of the problems facing the biodiversity, ecosystem-services and human-welfare chain. These could provide the basis for prioritizing how to address the questions posed at the outset of the Potsdam process in March 2007.

1. The problem of biodiversity loss is increasingly urgent in terms of the rate and costs of loss and the risks of crossing "tipping points".

2. Our growing, if still fragmented, understanding is often sufficient warning to support action.

3. We have time to act but that time is fast diminishing.

4. Seemingly small changes in one place can have huge though largely unpredictable impacts elsewhere.

5. In all cases the poor are bearing the brunt of the situation.

The classic development challenge of increasing economic opportunity and providing goods and services is still with us, but it has now been sharpened by the emerging recognition of global ecological constraints. Similarly, social justice will be threatened if the world continues to deepen the gulf between those who have the use of ecological goods and services and those who do not. Resentment over inequitable use of the planet's resources could erode international collaboration and trust, undermining the benefits of an integrated global economy and even threatening its very existence.

Acting to reduce ecological deficits before being forced to do so is far preferable to the alternative. If we plan reductions by cutting demand for ecological resources, this need not necessarily entail hardship, and may even add growth opportunities to the economy and improve quality of life. On the other hand, as many telling examples from history show, when societies that operate with an ecological deficit experience unplanned reductions in resource use and are forced to rely on their own "biocapacity", a decline in quality of life, often severe, generally follows (Diamond 2005).

There is still time to act. A wide variety of strategies and approaches are already being used to drive technological and organizational solutions that reduce human demand on nature. These include:

- Natural Step (www.naturalstep.org), biomimicry (Benyus 1997);
- Factor 4/Factor 10 (www.factor10-institute.org);
- Natural Capitalism (Hawken et al. 1999);
- Cradle to Cradle Design (www.mbdc.com), industrial ecology (www.is4ie.org);
- zero emissions (http://www.zeri.org/); and
- waste initiatives, sustainable architecture and so on.

Social technologies are also being developed. For example, ecological tax reform helps society shift from taxing "work" to taxing "waste" (Pearce et al. 1989).

Since the apparent unsustainability of society's current growth path has often been guided by economic metrics that ignore market and regulatory failures, and accompanied by a policy framework that does not achieve adequate conservation of biodiversity and ecosystems, we must ask two basic questions. First, what are the economic tools we need to guide us towards a sustainable, ecologically secure future? Second, how can this economics "toolkit" help us to evaluate and reform policies in order to achieve sustainable development, ecological security, and an accompanying level of conservation of ecosystems and biodiversity?

The following chapters attempt to address these crucial questions. In Chapter 3 we examine how the economics of ecosystems and biodiversity can be used to value the unaccounted benefits and costs of biodiversity conservation, and in Chapter 4 we explore some illustrative working examples of how economics can better inform us of the policies for the future.

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3 TOWARDS A VALUATION FRAMEWORK

The previous chapter demonstrated the many dimensions of the continuing decline of ecosystems and biodiversity, its significant human impact and the urgent need for action. Here we consider how the failure to recognize the economic value of wild nature has contributed to this continuing decline. We evaluate the challenges of placing economic values on the benefits of ecosystems and biodiversity that are not currently captured, and consider vital issues of ethics and equity which need to be at the heart of such evaluation. This chapter identifies the difficulties in evaluating ecosystem services and the main aspects of work we will carry out in Phase II, when we will focus on addressing these difficulties while firming up both a preferred framework and methodologies for estimating ecosystem and biodiversity values.

MANY FAILURES, ONE PROBLEM

Biodiversity loss and ecosystem degradation continue, despite the fact that policy makers, administrators, NGOs and businesses around the world have been seeking ways to stem the tide. There are many reasons for this, but perverse economic drivers as well as failures in markets, information and policy are significant factors. Markets tend not to assign economic values to the largely public benefits of conservation, while assigning value to the private goods and services the production of which may result in ecosystem damage.

The term **market failure** can cover anything from the lack of markets for public goods and services (called **public goods failure**, e.g. absence of "markets" for species conservation or for most of the regulating and supporting services of ecosystems) to imperfections in structure or process around markets which cause inefficiency and distortions (e.g. it can be argued that some price distortions in today's carbon markets are attributable to timid emissions caps). Furthermore, there is potential for market-based instruments to produce results that are socially unacceptable – carbon markets could be said to have helped legitimize global greenhouse gas emission levels (42 billion tonnes), that are perhaps five times the Earth's ability to absorb such gases (Stern 2006).

The size of the challenge of market failure should not be underestimated: for some services (e.g. scenic beauty, hydrological functions and nutrient cycling) it is difficult even to obtain a profile of demand and supply. There is an element of information failure here which leads to market failure.

There are many cases across the globe where information failure is overcome by measures such as environmental impact assessments (EIA). They can provide arguments that lead to less destructive options being taken. The viability of road-building projects connecting Mexico and Guatemala through the Mayan forest (see Box 3.1) was challenged on economic grounds. In India, information provided to the Indian Supreme Court on the value of ecosystems and biodiversity helped enshrine rates of compensation for forest conversion that will make it more difficult for approving authorities to take decisions that destroy public value. Nevertheless, information failure is common. For example, local authorities grant land conversion permits that lead to the fragmentation of habitats or damage to ecosystems for marginal private economic gain. Decision makers often have insufficient facts, tools, arguments or support to take a different decision and avoid biodiversity loss. This is particularly unfortunate since much of the lost biodiversity was of greater benefit to the region than the private gains. There are many cases of local economy and local societal losses in the interests of short-term private gain.

Lack of secure property rights is another cause of market failure. Many people in developing countries may have weak

Box 3.1: Mayan Forest Road Projects: market failure from information failure

Road-building projects in the Mayan Biosphere Reserve to connect Mexico and Guatemala were subjected to a cost-benefit evaluation. Up to an estimated 311,000 hectares of jaguar habitat were found to be at risk of deforestation due to these projects. Some of the projects were shown to have negative rates of return on investment on the basis of project economics, whilst others would be negative if only the carbon dioxide emissions (225 million tonnes over 30 years) were accounted for. A fuller evaluation including biodiversity values would have tilted the conclusions more firmly in the direction of continued conservation rather than road development.

Dalia Amor Conde,

Duke University, personal communication, 27 April 2008 legal rights over the lands on which they live and work. This may become an incentive to "mine" these lands rather than to manage them sustainably.

Policy failures arise due to incentives encouraging harmful action. Tax incentives and subsidies can lead to the market working for the destruction of natural capital, even where natural assets offer a sustainable flow of services to the economy and to society. Environmentally harmful subsidies (EHS, see Chapter 4 on subsidies) discriminate against sound environmental practices while encouraging other, less desirable activities. Fisheries are an example of this (see Box 3.2). Such subsidies are often economically inefficient, prompting growing calls for reform.

Policy failures also arise when the system of incentives fails to reward those who work to improve the environment, or fails to penalize those who damage it. Many agricultural practices can support high-value biodiversity. But without appropriate recognition, for example through payments for environmental services (PES), some good practices risk disappearing.

There are often no mechanisms for winning compensation from those who damage the environment for those who have lost as a result. Upstream mining activities do not generally pay those downstream for the fish they can no longer eat, or for health impacts. While such failures are still the norm, there is a shift in some countries. Costa Rica is the poster child for PES (see Chapter 4, Box 4.3), although the approach is widely used in developed countries as well in the form of agri-environment subsidies. Overall, benefit sharing is becoming a more acceptable concept, and liability and compensation payments are sometimes offered at levels that begin to act as real incentives. We elaborate on these aspects in the following chapter.

Lastly, due to population pressures, poverty and weak enforcement of protection, development policies sometimes indirectly result in natural ecosystems being converted into agricultural or urban landscapes in situations where, for social and environmental reasons, these are not the optimal choices. This is an example of policy failure driven by institutional failure and information failure. Formal and informal networks and rules are needed to support responses to policies which effectively manage ecosystem services. The costs of such institutional frameworks can be called policy costs and we return to this topic later in the chapter.

But before we discuss and analyse benefits and costs, we would like to recognize three important issues – risks, uncertainty, and the principle of equity – which must be addressed. Not only do they influence analysis, evaluation and the design of solutions for the various failures we have outlined above, but because they are in essence deep ethical issues, they translate into underlying assumptions for our analytical framework. We show that selecting an appropriate discount rate, a vital component of any cost-benefit analysis, is the outcome of implicit or explicit ethical choices.

ECONOMICS, ETHICS AND EQUITY

"Economics is mere weaponry;
its targets are ethical choices."
Sanjeev Sanyal, Director, GAISP

Economics has developed techniques to deal with risks, uncertainty and questions of equity. Discounting is a key tool in many conventional economic analyses because it helps to assess the value of cash flows resulting from decisions taken now. Conventional economic approaches can also be important in valuating biodiversity, but they cannot necessarily be applied routinely because of the potentially extreme consequences of biodiversity decisions. We outline below the complexities of applying economics in a field such as biodiversity.

Box 3.2: The effect of subsidies on fisheries

Subsidies are considered to be one of the most significant drivers of overfishing and thus indirect drivers of degradation and depletion in marine biodiversity.

- Subsidies fund fisheries expansion. Globally, the provision of subsidies to the fisheries industry has been estimated at up to US$ 20-50 billion annually, the latter roughly equivalent to the landed value of the catch.
- Over half the subsidies in the North Atlantic have negative effects through fleet development. This includes decommissioning subsidies, which have been shown usually to have the effect of modernizing fleets, thereby bringing about an increase in their catching powers.
- While fishing vessel populations stabilized in the late 1990s, cheap fuel subsidies keep fleets operating even when fish are scarce.
- The Common Fisheries Policy of the European Community, for example, allows for vessels to be decommissioned to reduce effort in some countries while simultaneously subsidizing others to increase their fishing capacity.

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RECOGNIZING RISKS AND UNCERTAINTY

The treatment of climate change by the *Stern Review* surfaced an issue which had been widely recognized but not tackled squarely: how to assess a roll of the dice, when one of the outcomes is the end of civilization as we know it?

This dilemma also applies to assessing the risks of ecosystem collapse. The difficulty was highlighted when one academic study (Costanza et al. 1997) estimated the economic value of ecosystem services at US$ 33 trillion (compared to US$ 18 trillion for global GDP). This result was criticized on the one hand for being far too high, but on the other hand for being "a significant underestimate of infinity" (Toman 1998).

Expressed in the language of finance, the global economy is "short an option" on climate change and on biodiversity and needs to pay a premium to buy protection. The *Stern Review*'s most quoted result, that a 1% per annum cost would be needed to protect the world economy from a loss of up to 20% of global consumption, is an example of such an "option premium".

Table 3.1: Valuing a "biodiversity option"

Measures of:	Financial option	"Biodiversity option"
a) Current value	Spot price	All variables – current state
b) Level of protection	Strike price	All variables – future state
c) Life of protection	Expiration	Conservation horizon
d) Uncertainty	Implied volatility	Modelled uncertainty
e) Discounting	Interest rate	Social discount rate

This analogy with a financial option illustrates how complex it would be to price a "biodiversity option". All five input variables a) to e) for a financial option have market values, as against NONE of those for biodiversity.

In the case of biodiversity and ecosystem losses, the size of such premiums will depend on several aspects of the ecosystem in question: its current state, the threshold state at which it fails to deliver ecosystem services, its targeted conservation state, and our best estimate of uncertainties (see Table 3.1). This is an exceedingly complex exercise as there are no market values for any of these measures.

We described in Chapter 2 the alarming risks of "business-as-usual": the loss of freshwater due to deforestation, soil erosion and nutrient loss, losses in farm productivity, the loss of fisheries; health problems and poverty. Attempting to value these losses raises important ethical dimensions – especially about the value of human well-being in the future compared to now. We believe the economics of uncertainty and discounting can help to address these ethical issues.

DISCOUNT RATES AND ETHICS

We are addressing issues here (such as species extinction) where there is no universal agreement on the appropriate ethics. But the ethical nature of the issue is widely recognized. A group of ethics experts (IUCN Ethics Specialist Group 2007) recently framed the issue like this:

"If human behaviour is the root cause of the biodiversity extinction crisis, it follows that ethics – the inquiry into what people and societies consider to be the right thing to do in a given situation – must be part of the solution. However, ethics is rarely accepted as an essential ingredient and is usually dismissed as being too theoretical a matter to help with the urgent and practical problems confronting conservationists."

Economists discount any future benefit when comparing it to a current benefit. At one level, this is just a mathematical expression of the common-sense view that a benefit today is worth more than the same benefit in the future. But ethical considerations arise, for example when we consider giving up current income for the benefit of future generations, or the opposite: gaining benefits now at the expense of future generations.

Financial discount rates consider only the time value of money, or the price for its scarcity, and relate the present value of a future cash flow to its nominal or future value. Simple discount rates for goods and services consider just time preference, or the preference for a benefit today versus later. Social discount rates are more complex, and engage ethical aspects of a difficult choice: consumption now versus later, for society rather than for an individual. The preferences built into this choice cover the relative value of goods or services in the future when their benefit may be lower, or higher, than now, and that benefit might flow to a different person or to a future generation.

Box 3.3, overleaf, explains the basic concept of discounting and the paradox of the conventional economic approach.

DISCOUNTING AND INTERGENERATIONAL EQUITY

The *Stern Review* has highlighted the crucial importance of the choice of discount rates in long-term decisions that range beyond conventional economic calculations. The discount rate has even been described as the "biggest uncertainty of all in the economics of climate change" (Weitzman 2007).

Box 3.3: Discounting and the optimist's paradox

There are two main reasons for discounting. The first is called "pure time preference" by economists. It refers to the inclination of individuals to prefer 100 units of purchasing power today to 101, or 105, or even 110 next year, not because of price inflation (which is excluded from the reasoning) but because of the risk of becoming ill or dying and not being able to enjoy next year's income. Whatever the reason for this attitude, it should not apply to a nation or to human society with a time horizon in the thousands or hundreds of thousands of years. Economists have often criticized "pure time preference". The most famous critique against it was perhaps that of the Cambridge economist Frank Ramsey, in 1928.

In the context of growth theory, economists agree with the discounting of the future for other reasons. They might agree with Ramsey, that to discount later enjoyments in comparison with earlier ones is "a practice which is ethically indefensible and arises merely from the weakness of the imagination". But discount they will, as Ramsey himself did, because they assume that today's investments and technical change will produce economic growth. Our descendants will be richer than we are. They will have three, four or even more cars per family. Therefore, the marginal utility, or incremental satisfaction they will get from the third, fourth or fifth car, will be lower and lower. Discounting at the rate at which marginal utility decreases could be ethically justified.

Growth is then the reason for undervaluing future consumption and future enjoyments. Is it also a reason to undervalue future needs for environmental goods and services? It is not, particularly if we think of irreversible events. Economic growth might produce virtual Jurassic Theme Parks for children and adults; it will never resurrect the tiger if and when it goes.

Growth theory is economic theory. It does not take out from the accounts the loss of nature, nor does it exclude from the accounts the defensive expenditures by which we try to compensate for nature's loss (building dykes against sea-level rise induced by climate change, or selling bottled water in polluted areas).

If we try to add up the genuine increase of the economy because of positive technical changes and investments (which nobody would deny), and the loss of environmental services caused by economic growth, the balance would be doubtful. In fact, we step on the issue of incommensurability of values.

Discounting gives rise to "the optimist's paradox". Modern economists favour discounting not because of "pure time preference" but because of the decreasing marginal utility of consumption as growth takes place. The assumption of growth (measured by GDP) justifies our using more resources and polluting more now than we would otherwise do. Therefore our descendants, who by assumption are supposed to be better off than ourselves, perhaps will be paradoxically worse off from the environmental point of view than we are.

Joan Martinez-Alier 2008

This is because the events being considered will happen over periods of 50 years or more, and the effect of choosing different discount rates over such long periods is significant, as Table 3.2 shows. The effects of only small differences in the discount rate, applied to a cash flow of US$ 1 million in 50 years' time, are dramatic. A zero discount rate means the cost or benefit is worth the same now as it would be in 50 years, but small increases in the rate result in substantial reductions in the present value of the future cash flow. An annual discount rate of 0.1% produces a present value of 95% of the forward cash flow (US$ 951,253). Discounted at 4%, the result is only 14% of the future cash flow – just US$ 140,713.

Table 3.2: Discount rates and outcomes

50-year forward cash flow	Annual discount rate %	Present value of future cash flow
1,000,000	4	140,713
1,000,000	2	371,528
1,000,000	1	608,039
1,000,000	0.1	951,253
1,000,000	0	1,000,000

Applying a 4% discount rate over 50 years implies that we value a future biodiversity or ecosystem benefit to our grandchildren at only one-seventh of the current value that we derive from it!

If our ethical approach sees our grandchildren valuing nature similarly to our generation, and deserving as much as we do, the discount rate for valuing such benefits over such a time period should be zero. Unlike man-made goods and services which are growing in quantity (hence the argument to discount future units of the same utility), the services of nature are not in fact likely to be produced in larger quantities in future. Perhaps the discount rate for biodiversity and ecosystem benefits should even be negative, on the basis that future generations will be poorer in environmental terms than those living today, as Paul Ehrlich (2008) has suggested (see also Box 3.3). That raises important questions about present policies which assume significant positive discount rates (Dasgupta 2001; 2008). When incomes are expected to grow, goods or services delivered later are relatively less valuable (because they represent a smaller part of the future income). This supports the usual, positive discount factor. The opposite holds true when asset values or incomes are expected to fall – future goods and services will become more valuable than now. In the case of biodiversity it is questionable whether it will be equally, more or less available in future, and therefore even the direction of the discount rate is uncertain.

DISCOUNTING IN A WELFARE CONTEXT

In welfare economics the objective is to maximize the social benefits of consumption across all individuals, with "consumption" covering a broad range of goods and services, including health, education and the environment. Aggregating social utility across individuals is problematic and prone to value judgements such as comparing the value of consumption for a rich person versus a poor person.

What are "appropriate" discount rates for communities or countries with significant poverty and hardship? Focusing on poverty alleviation now means that the benefits and costs of today's poor are more valuable than those of future generations (who may live under better conditions). This is an ethical argument for high discount rates!

But if today's poor rely directly on the conservation of biodiversity for vital supplies such as freshwater and fuel-wood, is it then justifiable to provide more income options to today's rich if this would jeopardize these vital supplies? Consider some examples of ethically indefensible trade-offs. A forest ecosystem may be essential to the well-being of poor farming communities downstream – by providing nutrient flows, recharging aquifers, regulating seasonal water supply, preventing soil erosion and containing flood damage

Box 3.4: "GDP of the poor"

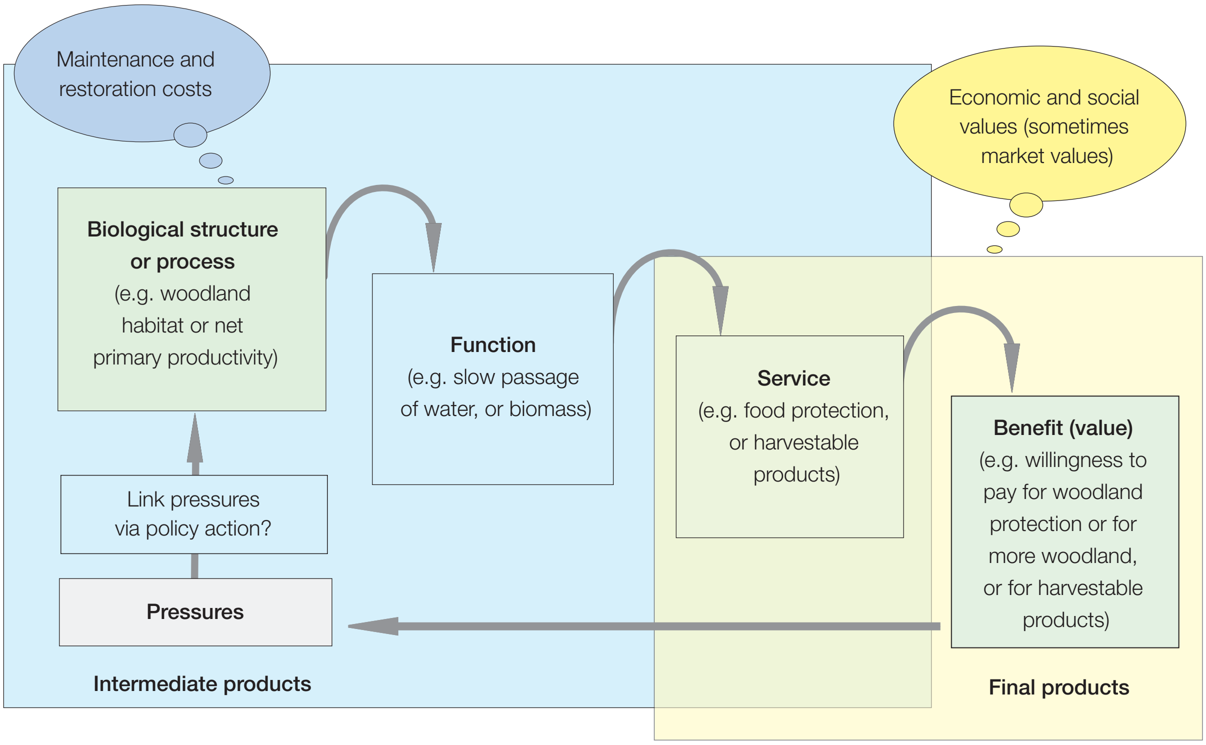
The full economic significance of biodiversity and ecosystems does not figure in GDP statistics, but indirectly its contribution to livelihood and well-being can be estimated and recognized. Conversely, the real costs of depletion or degradation of natural capital (water availability, water quality, forest biomass, soil fertility, topsoil, inclement micro-climates, etc.) are felt at the micro-level but are not recorded or brought to the attention of policy makers. If one accounts for the agricultural, animal husbandry and forestry sectors properly, the significant losses of natural capital observed have huge impacts on the productivity and risks in these sectors. Collectively, we call these sectors (i.e. agriculture, animal husbandry, informal forestry) the "GDP of the poor" because it is from these sectors that many of the developing world's poor draw their livelihood and employment. Furthermore, we find that the impact of ecosystem degradation and biodiversity loss affects that proportion of GDP most which we term the "GDP of the poor".

The end-use of ecosystem and biodiversity valuations in National Income Accounting, either through satellite accounts (physical and monetary) or in adjusted GDP accounts ("Green Accounts") does not of itself ensure that policy makers read the right signals for significant policy trade-offs. A "beneficiary focus" helps better recognize the human significance of these losses. In exploring an example (GAIS project, Green Indian States Trust 2004-2008) for this interim report, we found that the most significant beneficiaries of forest biodiversity and ecosystem services are the poor, and the predominant economic impact of a loss or denial of these inputs is to the income security and well-being of the poor. An "equity" focus accentuated this finding even further, because the poverty of the beneficiaries makes these ecosystem service losses even more acute as a proportion of their livelihood incomes than is the case for the people of India at large. We find that the per-capita "GDP of the poor" for India (using 2002/03 accounts and exchange rates) increases from US$ 60 to US$ 95 after accounting for the value of ecological services, and also that if these services were denied, the cost of replacing lost livelihood, equity adjusted, would be US$ 120 per capita – further evidence of the "vicious cycle" of poverty and environmental degradation.

We shall explore this approach for the developing world more broadly in Phase II. We believe that by using such sectoral measures and forcing a reflection of the equity principle by its "human" significance (given that most of the world's 70% poor are dependent on this sector) we shall focus adequate importance on policy making and contribute to a halt in the loss of biodiversity.

Gundimeda and Sukhdev 2008

Figure 3.1: The link between biodiversity and the output of ecosystem services



Source: Roy Haines-Young, presented by J-L Weber, the Global Loss of Biological Diversity, 5-6 March 2008, Brussels

and drought losses. It could be ethically difficult to justify destroying such a forest watershed in order to release economic value which has utility for the agents of destruction (e.g. profits from minerals and timber, related employment, etc.), whilst on the other hand, the costs of replacing ecosystem benefits forgone may be the same or less in monetary terms, but impossible to bear in human terms as they fall on poor subsistence farming communities (see Box 3.4). We see such situations as outcomes of bad economic targeting – *economics is mere weaponry, its targets are ethical choices*.

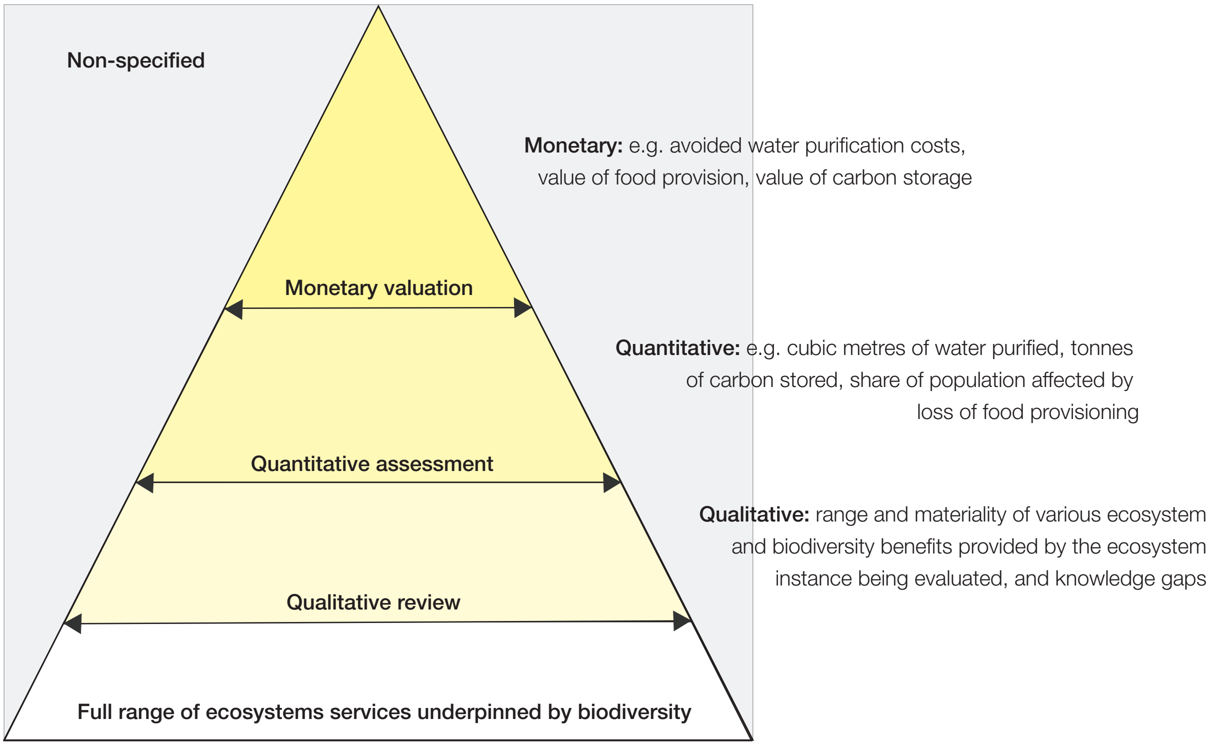
DISCOUNTING BIODIVERSITY LOSSES

We do not suggest that there are always defensible "trade-offs" for ecosystems and biodiversity, especially if significant ecosystems cease to function altogether as providers of provisioning or regulating services, or if biodiversity suffers significant extinctions. The evaluation of trade-offs using cost-benefit analysis and discounting works best for marginal choices involving small perturbations about a common growth path. However, the reality is that there are trade-offs, explicit or implicit, in any human choice. Even trying to set a boundary where trade-offs should not apply is itself a trade-off!

Trade-offs involve a choice between alternatives, and in the case of biodiversity losses, there are not always comparable alternatives. For development to be considered sustainable, a boundary condition called "weak sustainability" is defined, being a situation in which overall capital – natural, human and physical – is not diminished. But this also suggests that one form of capital can be substituted for another, which is not true: more physical wealth cannot always be a substitute for a healthy environment, nor vice versa. However, it is important for all aspects of the "natural capital" side of a trade-off at least to be appropriately recognized, valued and reflected in cost-benefit analysis, and even this is not yet being done in most trade-off decisions. There is a different boundary condition called "strong sustainability" which requires no net diminution of natural capital: this is more difficult to achieve, although compensatory afforestation schemes are examples of instruments designed to achieve strong sustainability. Finally, any trade-off has to be ethically defensible, and not just economically sound.

With biodiversity, we are not only considering long-term horizons as we are with climate change. Ecosystem degradation is already extensive and observable, and some of its effects are dramatic – such as the loss of freshwater causing international tension. Significant biodiversity losses and extinctions are happening right now, and flagship species such as the Royal Bengal tiger in India are under threat. A higher or lower discount rate can change the quantification of the social cost of imminent losses, but it would not alter the nature of the outcomes – loss of vital ecosystem services and valuable biodiversity.

Figure 3.2: Valuing ecosystem services



Source: P. ten Brink, Workshop on the Economics of the Global Loss of Biological Diversity, 5-6 March 2008, Brussels

In one of the accompanying papers of Phase I (IUCN 2008), approximately 200 valuation studies on forests have been examined. Many of these included some discounting of annuity flows in order to calculate an aggregate value for natural capital. We found that most studies used social discount rates of 3-5% or higher, and that none were below 3%. Our intention in Phase II is to leverage off this body of work, but to recalculate its results with different discounting assumptions.

Thus in Phase II we will propose a conceptual framework for the economics of biodiversity and ecosystem valuation which includes assessments of the sensitivity of ecosystem values to ethical choices. Our intention is to present a discrete range of discounting choices connected to different ethical standpoints, enabling end-users to make a conscious choice.

THE EVALUATION CHALLENGE

Economic evaluation can shed light on trade-offs by comparing benefits and costs and taking account of risks, and this can be applied to alternative uses of ecosystems. But there are many difficulties, which we set out in this section, and which we will address in Phase II.

Before economic valuation can be applied it is necessary to assess ecosystem changes in biophysical terms. Most benefits provided by ecosystems are indirect and result from complex ecological processes that often involve long lag times as well as non-linear changes (see Figure 3.1). Pressures may build up gradually until a certain threshold is reached, leading to the collapse of certain functions. A typical example is forest die-back caused by acidification. The impacts of pressures on ecosystems, including the role of individual species, the importance of overall levels of biodiversity, the relationship between the physical and the biological components of the ecosystem, and the consequences with regard to the provision of services, are difficult to predict.

Economic valuation builds on the biophysical understanding and aims to measure people's preferences for the benefits from ecosystem processes. These benefits may accrue to different categories of population over different geographical and time scales.

Our ability to assess the benefits provided by ecosystems, or the costs from their loss, is limited by lack of information at several levels. There are probably benefits that we have not yet identified, so we are able to assess, even in qualitative terms, only part of the full range of ecosystem services. We will probably never be able to assess the full range. It will be possible to make a quantitative assessment in biophysical terms only for part of these services – those for which the ecological "production functions" are relatively well understood and for which sufficient data are available. Due to the limitation of our economic tools, a still smaller share of these services can be valued in monetary terms.

Box 3.5: Putting it together – an example of a Cost of Policy Inaction study on biodiversity loss

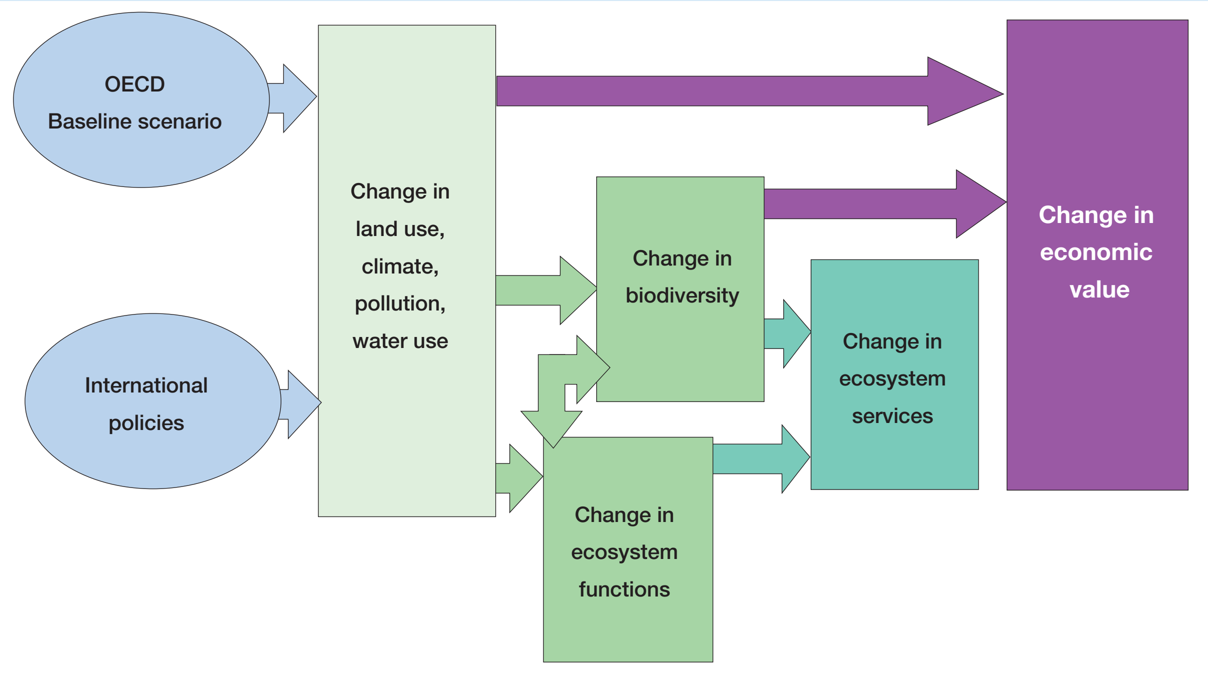
In November 2007, a consortium[1] started work on a "Cost of Policy Inaction" or COPI study (Braat, ten Brink et al. 2008) on the costs of not halting biodiversity loss. COPI's approach is the mirror image of benefits valuation, with the use of scenario analysis. Their terms of reference were to build up a global quantitative picture between now and 2050, and to try to value this in monetary terms.

The project succeeded in establishing an appropriate approach (see diagram), identifying the data gaps and the methodological problems, and providing indicative figures. Some interesting, be they only illustrative, results have been produced.

MODELLING BIODIVERSITY LOSS

The GLOBIO model was used to project changes in terrestrial biodiversity to 2050 (OECD 2008). The main indicators were changes in land use and quality and the mean abundance of the original species of an ecosystem (MSA), for all of the world's biomes. The model provides regional estimates for conversions from natural to managed forest and from extensive to intensive agriculture, and for the resulting decline in natural areas. The largest driver for conversions has historically been demand for agricultural land and timber, although infrastructure development, fragmentation, and climate change are predicted to become increasingly important. The expected loss of biodiversity by 2050 is about 10-15% (decline in MSA), the most extreme being in savannah and grassland.

Figure 3.3: Establishing a scenario analysis



It is therefore important not to limit assessments to monetary values, but to include qualitative analysis and physical indicators as well. The "pyramid" diagram in Figure 3.2 illustrates this important point.

Measurement approaches vary depending on what we measure. For provisioning services (fuel, fibre, food, medicinal plants, etc.), measuring economic values is relatively straightforward, as these services are largely traded on markets. The market prices of commodities such as timber, agricultural crops or fish provide a tangible basis for economic valuation, even though they may be significantly distorted by externalities or government interventions and may require some adjustments when making international comparisons.

For regulating and cultural services, which generally do not have any market price (with exceptions such as carbon sequestration) economic valuation is more difficult. However, a set of techniques has been used for decades to estimate non-market values of environmental goods, based either on some market information that is indirectly related to the service (revealed preference methods) or on simulated markets (stated preference methods). These techniques have been applied convincingly to many components of biodiversity and ecosystem services (an overview of the

The scenario used was largely developed by the OECD as its baseline (OECD 2008). It is broadly consistent with other modelling exercises such as those by the FAO or other UN agencies. The model itself forecasts a slowing rate of biodiversity loss in Europe (compared to an increasing rate worldwide).

ASSESSING CHANGES IN ECOSYSTEM SERVICES AND APPLYING MONETARY VALUES

Changes in land use and biodiversity are translated into changes in ecosystem services. The assessment relies to a large extent on the valuation literature, and creative solutions have been developed to extrapolate and fill data gaps. This is an area where further work is clearly needed in Phase II.

The biggest difficulty has been to find studies to monetize changes in ecosystem services. While there are many case studies, not all regions, ecosystems and services are equally covered, and there were often difficulties in identifying values per hectare for use in such a widespread benefit transfer. Also, most studies are based on marginal losses, and the values are often location specific.

THE VALUATION RESULTS

In the first years of the period 2000 to 2050, it is estimated that each year we are losing ecosystem services with a value equivalent to around EUR 50 billion from land-based ecosystems alone (it has to be noted that this is a welfare loss, not a GDP loss, as a large part of these benefits is currently not included in GDP). Losses of our natural capital stock are felt not only in the year of the loss, but continue over time, and are added to by losses in subsequent years of more biodiversity. These cumulative welfare losses could be equivalent to 7% of annual consumption by 2050. This is a conservative estimate, because:

- it is partial, excluding numerous known loss categories, for example all marine biodiversity, deserts, the Arctic and Antarctic; some ecosystem services are excluded as well (disease regulation, pollination, ornamental services, etc.), while others are barely represented (e.g. erosion control), or under-represented (e.g. tourism); losses from invasive alien species are also excluded;

- estimates for the rate of land-use change and biodiversity loss are globally quite conservative;

- the negative feedback effects of biodiversity and ecosystem loss on GDP growth are not fully accounted for in the model;

- values do not account for non-linearities and threshold effects in ecosystem functioning.

CONCLUSIONS AND NEXT STEPS

The study showed that the problem is potentially severe and economically significant, but that we know relatively little both ecologically and economically about the impacts of future biodiversity loss. Further work is envisaged in Phase II to address the points mentioned above, and further elaborate on the framework and methodology in line with our recommendations.

1. *The Cost of Policy Inaction (COPI): The case of not meeting the 2010 biodiversity target* (ENV.G.1/ETU/2007/0044) was carried out by a consortium led by Alterra, together with the Institute for European Environmental Policy (IEEP) and further consisting of Ecologic, FEEM, GHK, NEAA/MNP, UNEP-WCMC and Witteveen & Bos.

suitability of these methods to valuate ecosystem services is provided by the Millennium Ecosystem Assessment (2005b). But they remain controversial.

Fundamentally, there is the ethical question about the extent to which some life-supporting functions of biodiversity can be fully addressed by economic valuation and be considered as part of possible trade-offs instead of being dealt with as ecological constraints. Similarly, economic valuation may not be appropriate to address spiritual values. Keeping these limitations in mind, substantial progress has been made since the 1990s by economists working with natural scientists to improve these methods: there is increasing consensus on the conditions under which they can be used, and increasing confidence in the comparability of the results. These techniques are now commonly applied to measure a wide range of values, including many indirect and non-use values.

Another set of challenges relates to assessing the consequences of the loss of biodiversity and ecosystem services on a large scale. First, valuation methods generally do not cover second-round effects of the losses on the wider economy. To assess such effects, the use of economic models is necessary. While there are already some promising attempts (Pattanayak and Kramer 2001, Gueorguieva and Bolt 2003, Munasinghe 2001, Benhin and Barbier 2001), this is still very much an area of ongoing research. Secondly, most of the valuation evidence comes from individual case studies concerning a particular ecosystem or species. Some studies have tried to make a global assessment of the world's ecosystem services (e.g. Costanza et al. 1997) but, while they have been useful in raising attention and discussion, their results are controversial. Others focus at species or genera levels (Craft and Simpson 2001, Godoy et al. 2000, Pearce 2005, Small 2000). Any integral assessment on a broad scale raises substantial difficulties: how to define a coherent framework; how to deal with limitations in data; how to aggregate values to estimate the global impacts of large-scale changes in ecosystems.

In Phase II, we expect to rely on "benefit transfer" logic, i.e. using a value estimated in a particular site as an approximation of the value of the same ecosystem services in another site. Benefit transfer is easier for some homogeneous values (such as carbon absorption, which is a global good), than for others that are site-specific or context-dependent (such as watershed protection). However, we must recognize the trade-off between providing incomplete assessment on the one hand, and using inferred estimates (rather than primary research-based estimates) on the other.

For both ecological and economic reasons, caution is needed when scaling up and aggregating values estimated from small marginal changes to assess the effects of large changes. Ecosystems often respond to stress in a non-linear fashion. Large changes in ecosystem size or condition may have abrupt effects on their functioning, which may not be extrapolated easily from the effect of small changes. Generally, as some ecosystem services decline substantially as we continue to use them, extrapolation of benefits should recognize and be limited by the "law of diminishing returns".

THE COSTS OF BIODIVERSITY LOSS

There is a substantial body of evidence on the monetary values attached to biodiversity and ecosystems, and thus on the costs of their loss. A number of recent case studies and more general contributions have been received in reply to a call for evidence (see TEEB website http://ec.europa.eu/environment/nature/biodiversity/economics/index_en.htm for a list of submissions and a synthesis report).

Table 3.3: Projection of total benefits of carbon storage in European forests

	Latitude			
	35-45	45-55	55-65	65-71
Value per hectare (US$, 2005)	728.56	1,272.85	468.60	253.33

Source: ten Brink and Bräuer 2008, Braat, ten Brink et al. 2008

Box 3.6: The multiple values of coral reefs

Coral reefs provide a wide range of services to around 500 million people. Some 9-12% of the world's fisheries are based directly on reefs (Mumby et al. 2007), while a large number of off-shore fisheries also rely on them as breeding, nursery or feeding grounds (Millennium Ecosystem Assessment 2005c). Tourism generally is the dominant benefit. Reef recreation has been estimated at US$ 184 per visit globally (Brander et al. 2007), at US$ 231-2,700 per hectare per year in Southeast Asia (Burke et al. 2002) and at US$ 1,654 per hectare per year in the Caribbean (Chong et al. 2003). Coral reefs provide genetic resources for medical research, and ornamental fish and pearl culture are extremely important for the economies of some insular states, such as French Polynesia. The reefs protect coastal areas in many islands: this vital service has been estimated to be worth US$ 55-1,100 per hectare per year in Southeast Asia (Burke et al. 2002).

Sources: Ministère de l'Ecologie, du Développement et de l'Aménagement durables 2008, Braat, ten Brink et al. 2008, Balmford et al. 2008.

Our Phase I report COPI (Costs of Policy Inaction, Braat, ten Brink et al. 2008) made a first review of the general valuation literature and databases and tried to build up a global quantitative picture of biodiversity loss in biophysical and monetary terms (see Box 3.5, p36). A more targeted review of valuation case studies concerning forest ecosystems has also been made (IUCN 2008).

The existing valuation studies vary in their scope, quality, methodology, and suitability for use in a large-scale assessment. Often the estimated economic values are not comparable as they may be of a different nature or be expressed in different units, or the estimates may not be clearly related to a specific service or an area.

A particular effort is needed to assess indirect use values, especially those of regulating services, which are receiving increasing attention as a consequence of the Millennium Ecosystem Assessment. For carbon sequestration, substantial values have often been found, although they vary depending on the type of forest – for example deciduous or coniferous – and their geographical location.

Some significant values have been estimated for water regulation, although they are highly context-specific. The value of the watershed protection provided by intact coastal ecosystems, such as mangroves and other wetlands, has been estimated at US$ 845 per hectare per year in Malaysia and US$ 1,022 per hectare per year in Hawaii, United States of America. Overall, the values of the multiple watershed services tend to range from US$ 200 to 1,000 per hectare per year (Mullan and Kontoleon 2008). The value of bee pollination for coffee production has been estimated at US$ 361 per hectare per year (Ricketts et al. 2004), although the benefits only accrued to producers within 1 kilometre of natural forests. Many of the studies evaluating regulating services, for example for coastal protection or regulation of the water cycle, use production function approaches. These approaches are being increasingly refined, allowing better assessment of trade-offs between competing uses of ecosystems (see, for example, Barbier et al. 2008).

While there is increasing evidence of the value of some regulating services, many others, such as health regulation, have been little explored so far, although there are some indications that they might be significant (Pattanayak and Wendland 2007).

The economic importance of the contribution of aggregated biodiversity to ecosystem resilience (the capacity of an ecosystem to absorb shocks and stresses in constructive ways) is probably very high but still poorly quantified, although studies have analysed aspects such as the contribution of crop diversity to agricultural yields and farm income (e.g. Di Falco and Perrings 2005, Birol et al. 2005). This important gap in knowledge reflects the difficulty of first quantifying the risks of a system collapse from an ecological perspective, and then measuring people's willingness to pay to reduce those risks which are not yet well understood.

The real costs of the loss of biodiversity and ecosystems also include option values. Although they are difficult to measure, these values placed on conserving resources for possible uses in the future are significant because our knowledge of the importance of ecosystem services is expected to improve over time, and because part of the losses of biodiversity and the services it underpins are irreversible. A preferred methodology for measuring option values (in particular, bio-prospecting values) has been prepared as part of the preparatory work in Phase I (Gundimeda 2008). In Phase II, we propose to build on this approach.

THE COSTS OF BIODIVERSITY CONSERVATION

Losing biodiversity and ecosystem services might cause tremendous costs for society due to the subsequent loss of

Table 3.4: Results from studies on the costs of conservation

Source	Object	Assessed costs	Estimates
Frazee et al. 2003	Conserving the Cape Floristic Region (South Africa)	OC + MC	One-off US$ 522 million and annual expenses of US$ 24.4 million
Chomitz et al. 2005	Network of protected ecosystems (Bahia, Brazil)	OC	OC 10.000 ha
Wilson et al. 2005	Preservation of tropical forest (certain regions)	OC	Sumatra: US$ 0.95/ha/year Borneo: US$ 1.10/ha/year Sulawesi: US$ 0.76/ha/year Java/Bali: US$ 7.82/ha/year Malaysia: US$ 27.46/ha/year
Ninan et al. 2007	Non-timber forest product benefits (Nagarhole National Park, India)	OC	Net present value of US$ 28.23 per household annually
Sinden 2004	Biodiversity protection (Brigalow Belt, New South Wales)	OC	US$ 148.5 million
European Commission 2004	Biodiversity protection within the Natura 2000 network (covering 18% of EU25-territory)	MC + TC	EUR 6.1 billion annually over a 10-year period
Bruner et al. 2004	Expanding forest conservation to all priority areas (worldwide)	OC + MC	US$ 5.75/ha/year for 10 years

OC = opportunity costs TC = transaction costs MC = management costs various provisional and regulatory services such as food production, water regulation and climate change resilience. All these create the necessary arguments for biodiversity protection, while the rate of loss demands urgent action. But conservation, too, has a cost, which needs to be factored into decision making. Knowing these costs provides the basis for determining the relationship between costs and benefits, and for identifying the most cost-effective options of conservation.

A comprehensive cost assessment has to include various types of costs: biodiversity conservation may require use restrictions which lead to opportunity costs from foregone economic development; management costs arise for measures like, for example, fencing and breeding programmes, and transaction costs are associated with the design, implementation, and control policies for biodiversity conservation.

Globally, between US$ 8 billion and US$ 10 billion are invested annually in biodiversity conservation (James et al. 2001, Pearce 2007); protected areas take up a significant portion of these resources. At the global level, US$ 28 billion may be required annually over the next 30 years to expand IUCN priority habitats to 10% of the area of all countries (James et al. 2001). This cost estimate includes acquisition and management costs of the current and future biodiversity reserve sites. If the protected area system is expanded to cover key currently unprotected species and to meet biological/ecological needs, up to US$ 22 billion per year in management costs would be required (Bruner et al. 2004). But safeguarding the provisioning of ecosystem services and biodiversity benefits in protected areas could cost as little as two orders of magnitude less than the valued benefits of ecosystems and biodiversity. (Balmford et al. (2002) have taken this idea and proposed that, for the annual investment of US$ 45 billion – around a sixth of that needed to conserve all ecosystem services worldwide – we could protect natural services worth some US$ 5 trillion in protected areas: an extremely good benefit-cost ratio of 100:1.)

The costs of conservation vary between regions because of differences in their economies and cost structures. Conservation costs have been found to be as little as US$ 0.01 per hectare per year in remote areas and as high as US$ 1,000 per hectare per year in densely populated areas. The benefits of services derived from different ecosystems go from several hundred to over US$ 5,000 per hectare annually and in some cases much more. An extreme case is that of coral reefs, for which UNEP estimated an overall value of ecosystem services at between US$ 100,000 and US$ 600,000 per square kilometre; based on an estimated cost of US$ 775 per square kilometre for maintaining marine protected areas, the management costs of coral reefs could be as little as 0.2% of the value of the ecosystem protected (UNEP-WCMC 2007) – the opportunity costs of coral reef conservation are not included in this comparison. However, knowledge of the spatial distribution of benefits and costs of biodiversity protection is necessary to enable cost-effective conservation of ecosystem services.

Although the figures available so far apply to small bits of nature here and there, policy makers want the big picture. When the Natura 2000 network of protected areas started to emerge in the European Union, one common thread was the costs of managing it and delivering on the targets. The cost of implementing this network of protected sites, which then accounted for 18% of the EU-25 territory, has been estimated at over EUR 6 billion annually (European Commission 2004). These costs included management, restoration and provision of services (like recreation and education), but excluded expenditures for buying up land for nature. The overall costs of conservation are higher if we include philanthropy and subsidies. For example, in the United States of America, private charity to "environment and animals" was estimated at US$ 9 billion in 2005 (Giving USA 2006).

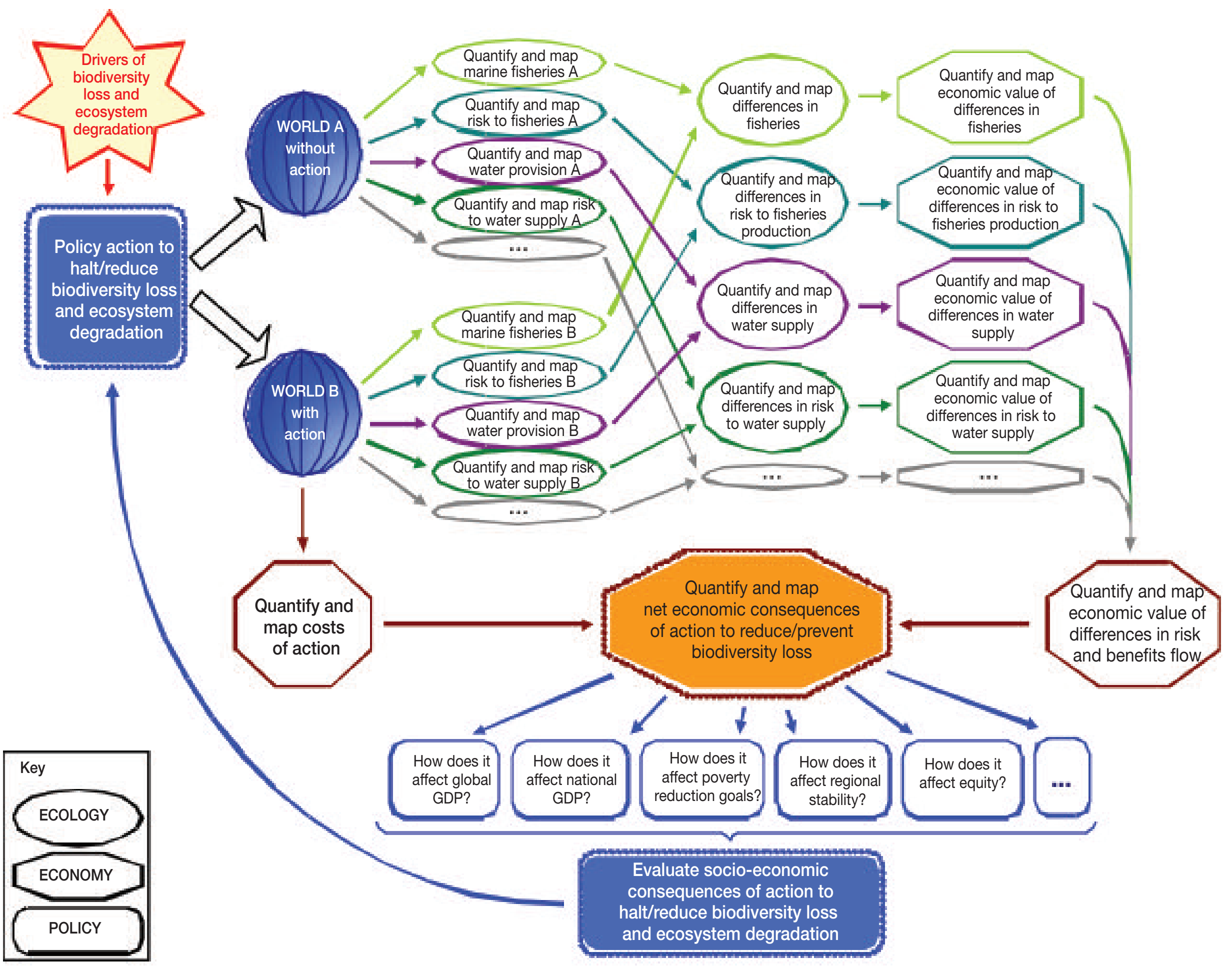
Protected areas in developing countries are considerably cheaper per hectare to establish and manage than in developed countries. Thus, although developing countries account for 60% of the total area of biodiversity reserve sites, their actual conservation budget needs come to just 10% of the global budget (James et al. 1999).

The costs of achieving a given conservation target depend on the chosen policy instruments and their designs. In testing this assumption, it was found that simply using a different design for a conservation instrument can yield cost-savings of up to 80% for a given species coverage. A necessary, but not sufficient, prerequisite for cost-effective spending is that conservation spending conforms to current conservation priorities. Only 2-32% of spending patterns by conservation agencies can be explained by the guidelines for prioritizing biodiversity conservation (Halpern et al. 2006).

Another point to be considered is the spread of resources needed between different portions of biodiversity. In economic terms, it appears that the marginal costs of conservation investments are increasing: that is, while the first "units" of conservation can be bought at a low cost, each additional unit costs more. However, researchers believe that "low-hanging fruits" are available in biodiversity conservation. Saving a large number of species is relatively cheap, but costs may explode as the last few species, habitats or ecosystems are included in conservation targets.

The general scarcity of studies pointing to the benefits and costs of biodiversity conservation, especially at regional and local levels, contributes to the non-allocation of sufficient resources for conservation and to the observed budget shortfalls. Only a very limited number of studies have assessed simultaneously the benefits and costs of protecting

Figure 3.4: Proposed valuation framework: contrasting appropriate states of the world



biodiversity and ecosystem services in specific conservation projects. Some studies have been area-specific, like the assessment of protecting ecosystem services in Madagascar, which revealed that the country's biodiversity provides a wide array of services that brings benefits of a value twice as high as the management costs of biodiversity resources on the island. Other studies have been sector-specific: for example, it has been estimated that a global marine protected area system, accounting for the closure of 20% of total fishing area and resulting in a lost profit of US$ 270 million per year (Sumaila et al. 2007), would help sustain fisheries worth US$ 70-80 billion per year (FAO 2000) while creating 1 million jobs (Balmford et al. 2004). Furthermore, the methodology used for studies on conservation costs often lacks some common understanding of what to include and how to measure these costs. The resulting picture of conservation economics is incomplete and a spatially explicit method for distributing conservation funding is missing (Bruner et al. 2008).

Although conservation of biodiversity appears economically reasonable, current global expenditures (estimated at US$ 10-12 billion annually) fall short of expected needs. Because conservation, mainly in developing countries, suffers from budget shortfalls, developing countries should get priority when allocating additional money for global biodiversity conservation to enhance the effectiveness of their protection measures. However, as conservation goals for developing countries are often seen to compete with their development goals, there are important societal issues to address in a local context: property rights versus access rights and usufruct rights, rights for local residents versus rights for migrant and neighbouring poor, livelihood and welfare issues, and the persistence of the "vicious cycle" of poverty and environmental degradation. In addressing these issues in Phase II, we have to recognize policy overlaps that will affect the viability of an economic toolkit for policy makers in the developing world.

PROPOSED VALUATION FRAMEWORK

The considerations explained in this chapter have led to a valuation framework (see Figure 3.4) which we propose to use in Phase II, in conjunction with our meta-analysis of valuation studies, so that we can prepare a globally comprehensive and spatially specific framework and estimation grid for the economic valuation of ecosystems and biodiversity. It is based on the science study (Balmford et al.

2008)[1] and the issues of ethics, equity and the discount rate discussed earlier.

These are the key elements of our proposed framework:

- **Examine the causes of biodiversity loss:** designing appropriate scenarios to evaluate the consequences of biodiversity loss means incorporating information on the drivers of this loss. For example, loss of marine fisheries is driven by overfishing, so it would be appropriate to compare a scenario of business-as-usual (continued overfishing) with one where fisheries are sustainably managed. Evidence suggests that biodiversity is often being lost even where it would be socially more advantageous to preserve it. Identifying the market, information and policy failures can help us identify policy solutions.

- **Evaluate alternative policies and strategies that decision makers are confronted with:** the analysis needs to contrast two or more "states" or scenarios that correspond to alternative action (or inaction) to reduce biodiversity and ecosystem loss (World A and World B). This approach is also used in impact assessments and cost-benefit analyses to ensure that decision makers can make informed decisions on the basis of a systematic analysis of all the implications of various policy choices.

- **Assess the costs and benefits of actions to conserve biodiversity:** the analysis will need to address both differences in benefits obtained from biodiversity conservation (e.g. water purification obtained by protecting forests) and in the costs incurred (e.g. foregone benefits from conversion of the forest to agriculture).

- **Identify risks and uncertainties:** there is much that we do not know about how biodiversity is valuable to us, but that does not mean that what is not known has no value – we risk losing very important, but still unrecognized, ecosystem services. The analysis needs to identify these uncertainties and assess the risks.

- **Be spatially explicit:** economic valuation needs to be spatially explicit because both the natural productivity of ecosystems and the value of their services vary across space. Furthermore, benefits may be enjoyed in very different places from where they are produced. For example, the forests of Madagascar have produced anti-cancer drugs that save lives all over the world. Besides, the relative scarcity of a service, as well as local socio-economic factors, may substantially affect the values. Taking into account the spatial dimension also allows for better understanding of the impacts of conservation on development goals, and for the exploration of trade-offs between the benefits and costs of different options, highlighting regions that may be cost-effective investments for conservation.

- **Consider the distribution of impacts of biodiversity loss and conservation:** the beneficiaries of ecosystem services are often not the same as those who incur the costs of conservation. Mismatches can lead to decisions being taken that are right for some people locally, but wrong for others and for society as a whole. Effective and equitable policies will recognize these spatial dimensions and correct them with appropriate tools, such as payments for ecosystem services.

Figures 3.5 and 3.6 illustrate the multi-scale dimension of ecosystem services and thus the need to account for the spatial pattern in their production and use. Even large cities like London depend on a diversity of benefits produced by ecosystems and biodiversity, often at a considerable distance.

This framework will be used during Phase II but it will not be possible to collect information for the elaboration of detailed maps for all types of ecosystem services and biomes. Thus the evaluation will also largely rely on "benefits transfer", making clear the assumptions and defining carefully the conditions for extrapolating from limited data, taking into account the scale and distance-dependency of the various services. Spatial data bases will be used, highlighting where data gaps need to be filled.

BRINGING TOGETHER THE ECOLOGICAL AND ECONOMIC ASPECTS IN OUR VALUATION FRAMEWORK

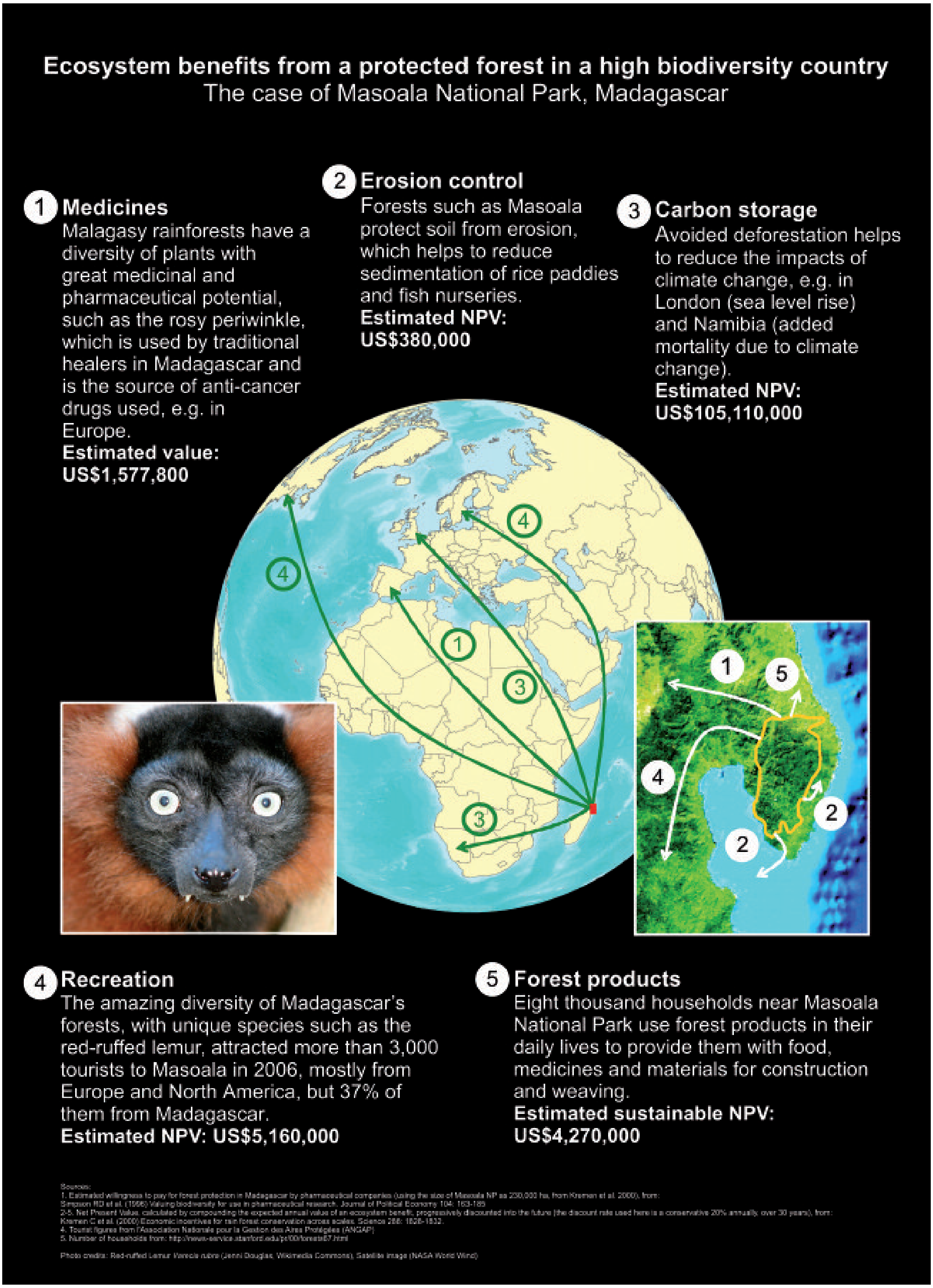
Valuing ecosystems requires integration of ecology and economics in an interdisciplinary framework. Ecology should provide the necessary information on the generation of ecosystem services, while economics would bring the tools for estimating their values (see Figure 3.4).

Valuation of regulating ecosystem services and some provisioning services must be based on an understanding of the underlying biological and physical processes that lead to their provision. For example, to be able to valuate the water regulation provided by a forest, it is first necessary to have information about the land use, the hydrology of the area and other characteristics, in order to make a biophysical assessment of the service provided.

Such an understanding makes it possible to estimate economic value, but there are some challenges which need to be addressed:

- Measuring the quantity and quality of services provided by ecosystems and biodiversity in various possible states is a key challenge, and also an opportunity, to avoid the pitfalls of generalization. Valuation is best applied to alternative states or scenarios (e.g. services provided under differing land-use practices reflecting different policy scenarios). For example, the conser-

Figure 3.5: Ecosystem benefits from a protected forest, Madagascar



Source: Balmford et al. 2008

Figure 3.6: Ecosystem benefits to Greater London, UK

Source: Balmford et al. 2008

vation of tropical forest catchments might provide net benefits to water compared to the same area as grazing land or cropland, but these benefits might not exceed the benefits of agroforestry on the same piece of land (Chomitz and Kumari 1998, Konarska 2002). Estimating extant biodiversity in these different scenarios would add another layer of challenge. It would be important to scope such scenario-based assessment appropriately, to ensure that the main purpose of our valuations (estimating the costs and benefits of conservation of biodiversity) is not lost in modelling alternative land uses.

- Non-linearity in the flow of services needs special attention. For example, recent studies on coastal mangroves in Thailand have taken into account that the ecosystem service providing coastal protection does not vary in line with the area of natural mangrove. This leads to significantly different values and policy conclusions compared to previous studies, notably on the optimal mix between conservation and development (Barbier et al. 2008). Another important aspect is the existence of threshold effects and the need to assess how close an ecosystem may be to the collapse of certain services. There are still major gaps in scientific knowledge about the role of species in ecosystems and what the key factors are for producing flows of beneficial ecosystem services and ensuring their resilience. However, for some services, there is evidence on the influence of certain biophysical indicators (habitat areas, indicators of health, species diversity, etc.). The Scoping the Science study (Balmford et al. 2008) has reviewed the state of ecological knowledge on a series of ecosystem services and assessed the available information. The findings of this study – which will be added to in Phase II – will provide a basis for the economic evaluation by means of:
  - o building appropriate scenarios for the provision of each ecosystem service;
  - o defining for at least a set of services the method for generating a global quantification and mapping of service provision under different scenarios, upon which to base the economic valuation;
  - o formulating reasonable assumptions to allow for the extrapolation of values estimated for certain ecosystems so as to fill data gaps.

- The links between ecosystem processes and the benefits they provide to people vary in complexity and directness. A classification system is needed, and can be developed from the system built in the context of the Millennium Ecosystem Assessment (2005b), which can still be improved to provide a good basis for economic valuation (following, for example, Boyd and Banzhaf 2007, Wallace 2007, Fisher et al. in press). It appears useful to distinguish between "final" services (e.g. crop provision, clean water provision) that provide benefits directly relevant for human welfare, and "intermediate" services that serve as inputs for the production of other services (e.g. pollination, water regulation). The economic value of pollination, for example, cannot be assessed separately from that of the provision of crops. An end-user perspective must be adopted: the value of intermediate services can only be measured through their contribution to the production of end-user benefits. We intend to structure the classification of services for the evaluation in Phase II around this perspective.

KEY PRINCIPLES OF BEST PRACTICE ON THE VALUATION OF ECOSYSTEM SERVICES

These principles build on the recommendations made at the Workshop on the Economics of the Global Loss of Biological Diversity organized in the context of this project in Brussels in March 2008 (ten Brink and Bräuer 2008).

1. The focus of valuation should be on marginal changes rather than the "total" value of an ecosystem.

2. Valuation of ecosystem services must be context-specific, ecosystem-specific, and relevant to the initial state of the ecosystem.

3. Good practices in "benefits transfer" need to be adapted to biodiversity valuation, while more work is needed on how to aggregate the values of marginal changes.

4. Values should be guided by the perception of the beneficiaries.

5. Participatory approaches and ways of embedding the preferences of local communities may be used to help make valuation more accepted.

6. Issues of irreversibility and resilience must be kept in mind.

7. Substantiating bio-physical linkages helps the valuation exercise and contributes to its credibility.

8. There are inevitable uncertainties in the valuation of ecosystem services, so a sensitivity analysis should be provided for decision makers.

9. Valuation has the potential to shed light on conflicting goals and trade-offs but it should be presented in combination with other qualitative and quantitative information, and it might not be the last word.

In Phase II, we will exploit existing valuation literature in greater depth and develop a methodology for choosing valuation techniques for different benefits, and for applying benefit transfer and aggregation. The work will build on the framework described in this chapter and will refine it in these ways:

1. It will focus on the contribution of services to final benefits to people, thus **avoiding double counting**.

2. There will be a clear **"spatial focus"** – on the locations where the services and benefits arise.
3. It will **identify risks** by noting the fragility of an ecosystem and whether it is judged to be near thresholds, and will reflect this in selecting a valuation approach, recognizing the limitations of conventional analysis where changes are not marginal.

4. Likewise, for estimating stock values from ecosystem service flows, it will **recognize the limitations of discounting** where we are not looking at small variations along a given growth path.

Finally, we should affirm here that valuation is not an end in itself, and should be oriented towards the needs of end-users. This includes policy makers and decision makers at all levels of government. It also includes corporate and consumer organizations, since private-sector actors are significant users of biodiversity benefits and potential stewards of biodiversity and ecosystems.

Our effort in Phase II will be to engage these end-users to ensure that our output – the final report on **The Economics of Ecosystems and Biodiversity** – is relevant, purposeful and effective in ensuring an appropriate reflection of the economic value of biodiversity. Our emphasis on end-users brings us to focus the policy-relevance of our economic evaluations, and much of Chapter 4 is a preview of examples where we have seen good economic estimations and logic being used to support better policies for the conservation of ecosystems and biodiversity.

End notes

1. The *Scoping the Science* study had the University of Cambridge as scientific lead, and was done in collaboration with the Institute for European Environmental Policy (IEEP), United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and Alterra-Wageningen University and Research Centre.

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4 FROM ECONOMICS TO POLICIES

Society's defective economic compass can be repaired with appropriate economics applied to the right information. This will allow existing policies to be improved, new policies to be formed, and new markets to be created: all of which is needed to enhance human well-being and restore the planet's health.

In the last chapter we described how biodiversity is seriously affected by policy – or a lack of policy. Since there are no markets for most of the "public goods and services" from biodiversity and ecosystems, their costs and benefits often fall to different actors or at different levels, as with all "externalities". There is little or no private reinvestment in maintaining and conserving these resources. The polluter often does not pay for causing losses to others. The subsidized fishing fleet depletes fish stocks well beyond levels that would occur in the absence of such subsidies. Vital services of forests – such as water provisioning and regulation, soil retention, nutrient flow, enhanced landscapes – do not reward the beneficiaries and are provided at much lower levels than desirable. The benefit of conserving a species for future generations is global, whereas costs for its conservation are local and uncompensated, and therefore it becomes extinct.

Despite all these "disconnects", there is room for optimism. During our Phase I studies, we observed several good policies already in place, in many countries, that address these issues. However, a more thorough consideration of the economics of biodiversity and ecosystem services is needed to make these solutions scalable and workable beyond their initial stages, "pilot" phases and current host locations.

The final report on The Economics of Ecosystems and Biodiversity (TEEB) will systematically address a comprehensive range of such policy options for better conserving biodiversity and ecosystem services, and will demonstrate how better policies result from applying and integrating the new economics of ecosystems and biodiversity. Here, we provide some examples to illustrate how the economic values of ecosystem benefits and costs can be internalized and used to help improve current policies or offer new options.

The examples come from diverse policy fields but they convey four broad messages, elaborated in the sections that follow:

- rethink today's subsidies to reflect tomorrow's priorities;
- reward unrecognized benefits, penalize uncaptured costs;
- share the benefits of conservation;
- measure what you manage.

RETHINKING TODAY'S SUBSIDIES TO REFLECT TOMORROW'S PRIORITIES

Subsidies exist across the globe and across the economy. They affect us all and many affect the health of the planet's ecosystems. Harmful subsidies must be reformed to halt biodiversity loss and achieve appropriate stewardship of the planet's resources.

Subsidies can support social and environmental innovation as well as technological and economic development. On the other hand they can result in private gain with no social benefits and can lead to economic inefficiency and market distortions. Worse, they can result in biodiversity losses and damage to ecosystems. In some cases, rational support for a social objective such as food security outlives its purpose, resulting in unnecessary economic and environmental costs.

Most subsidies are intentional and introduced for a clear, specific purpose, such as payments to develop commercial nuclear power in the 1950s and 1960s, and agricultural

Box 4.1: Environmentally harmful subsidies

The OECD defines subsidy as *"a result of a government action that confers an advantage on consumers or producers, in order to supplement their income or lower their costs".*

However, this definition ignores consequences for natural resources and does not cover subsidy as a result of inaction. **Environmentally harmful subsidies** are a result of a government action or inaction that: *"confers an advantage on consumers or producers, in order to supplement their income or lower their costs, but in doing so, discriminates against sound environmental practices".*

Box 4.2: Subsidies that distort trade

Trade policies influence global trends in biodiversity. Provisions for trade in agriculture and fisheries (e.g. favourable treatments or preferential tariffs) can have a significant effect on land and resource-use patterns across exporting and importing countries. International trade agreements, combined with export-oriented national policies, can cause countries to focus on exporting natural resources at an unsustainable level. For example, the EU Fishing Agreements have led to exhaustion of resources by EU vessels outside the EU, leading to unsustainable use of natural resources in these countries.

André Künzelmann/UFZ

support to rebuild devastated European agriculture after World War II. Many are permanent features – agricultural inputs and products are often subsidized directly, along with energy, food, transport and water.

Less obvious subsidies exist as accidental features of policies or lack of policies which means that the costs of damage to biodiversity and ecosystems are ignored. For example, water abstracted is rarely priced at its resource value, companies rarely pay for the value of genetic materials they build products on, and the cost of damage to forest or coastal areas is not generally paid for.

This has already begun to change. Although existing subsidies are well defended by vested interests, policy makers have recognized the importance of reforming them for environmental and economic reasons. Two avenues have proved to be promising. Subsidies can either be removed or reformed to promote environmentally friendly resource use – such as the changes to the agricultural subsidies in the United States of America and the European Union. Subsidies can be replaced, using private resources to sustain financial flows for certain land-use practices, as in the example of landscape auction in the Netherlands. Landscapes are broken down into distinct elements such as a tree, a hedgerow or a pond. While the landowner still owns the item, people bid at auction to support the conservation of a specific element and thereby raise money for its preservation. Thus both farmers' incomes and the conservation of biodiversity can be assured without state subsidies.

REWARDING UNRECOGNIZED BENEFITS, PENALIZING UNCAPTURED COSTS

Getting prices right is a cardinal rule for good economics. Since most biodiversity and ecosystem benefits are in fact public goods that have no price, this can be done in two ways: instituting appropriate policies (which reward the preservation of the flow of these public goods and penalize their destruction), and encouraging appropriate markets (mainly "compliance markets" which attach tradable private values to the supply or use of these goods and create incentive structures to pay for them). We highlight the example of payments for ecosystem services, and some nascent markets which could harness the power of supply and demand if appropriate infrastructure, incentives, financing and governance are provided.

PAYMENTS FOR ECOSYSTEM SERVICES

Payments for ecosystem services (PES) can create demand, a necessary market force to correct an existing imbalance which harms biodiversity and stymies sustainable development.

PES are payments for a service or the land use likely to secure that service (UNEP/IUCN 2007). Governments are increasingly creating incentive programmes that support landowners who protect ecosystem services by compensating for lost revenues (Millennium Ecosystem Assessment 2005). Payments are particularly valuable when land cannot be purchased and set aside for conservation, or where protected areas cannot be established.

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Payments can be international (IPES). One prominent example is the Clean Development Mechanism (CDM) that operates under the Kyoto Protocol. The Bali COP agreed to consider REDD (projects to Reduce Emissions from Deforestation and Forest Degradation) as part of the post-2012 regime. This is an important milestone, as it addresses the 18-20% of global greenhouse gas emissions from tropical deforestation and related land-use change (CAN 2008). Preventing deforestation and creating and restoring forests can simultaneously protect biodiversity and ecosystem services as well as countering climate change.

But significant funding is needed – possibly US$ 10 billion a year to achieve a substantial impact on deforestation rates (Dutschke and Wolf 2007) – and there is still uncertainty about how to implement REDD and the scale of its ambitions (Miles 2007). Suitable financial mechanisms need to be designed to stimulate activity. One option is a market-based mechanism which would allow credits in avoided deforestation to be traded. The advantages of an early start with pilot schemes have to be weighed against the risks of leakage of deforestation pressure to neighbouring forests.

REDD can significantly reduce greenhouse gas emissions at low cost, and at the same time help to conserve forests and their biodiversity. However, potential risks from knock-on effects must be considered. REDD is unlikely to include support for ecosystem services other than carbon storage, and other services could be damaged by displaced deforestation pressures. For example, pressures to remove fuelwood and fodder from a degraded forest that has come under the purview of REDD could shift to a neighbouring forest area with healthier ecosystems and more biodiversity, which then would suffer. REDD could achieve reductions in emissions, but at the cost of biodiversity loss.

PES can be substantial and support mainstream biodiversity policies. The US government spends more than US$ 1.7 billion a year in direct payments to farmers for

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Box 4.3: Payments for environmental services in Costa Rica

From 1997 to 2004 Costa Rica invested around US$ 200 million in its PES programme, protecting over 460,000 hectares of forests and forestry plantations and indirectly contributing to the well-being of more than 8,000 people. A series of associations and partnerships at national and international level were built around the programme, contributing to its long-term financial sustainability.

The PES programme in Costa Rica is practically a national strategy for forest and biodiversity conservation and sustainable development. It has been a powerful tool to demonstrate the additional values of forest ecosystems rather than just the wood, and has thus offered incentives for the producers to provide these values. Legislation compensates for four environmental services: greenhouse gas mitigation, water services, scenic value and biodiversity.

The PES programme has contributed to reducing deforestation and has at the same time reactivated the forestry industry.

Portela and Rodriguez 2008

environmental protection (Kumar 2005). Payments under the Department of Agriculture's Environmental Quality Incentives Program encourage sustainable use of irrigation, nutrients and fertilizers, integrated pest management and wildlife protection. Similarly, the European Union mechanism for promoting environmentally friendly agriculture and forestry is a major part of the EU Rural Development programmes (European Commission 2005), worth some EUR 4.5 billion annually (European Commission 2007). In 2005, agri-environment schemes covered an area reaching 36.5 million hectares for EU-27 (excluding Hungary and Malta), through 1.9 million contracts with farmers. PES can give communities the chance to improve their livelihoods through access to new markets. A feature of success is to combine "carrot and stick" by introducing protective legislation in conjunction with conservation incentives. This can be particularly significant for people in developing countries (see Box 4.3).

EXTENDING THE "POLLUTER PAYS" PRINCIPLE

There is an increasing trend to use damage valuations to address degradation of biodiversity and ecosystem services. The polluter is frequently required to pay for damage caused, either through bearing the actual costs of clean-up and restoration projects, or through court-determined punitive damages. Significant examples include:

Norma Neuheiser, UFZ

- the Exxon-Valdez spill – a 7,800-square-kilometre oil slick that still affects Alaska's fisheries, costing the polluter US$ 3.4 billion of penalties, clean-up costs and compensation (*Space Daily* 2008).

- Guadiamar River – the main water source for the Doñana National Park salt marshes in Spain, which suffered from the devastating failure of a dam in Aznalcóllar mine, releasing toxic muds for which clean-up and restoration efforts cost the Spanish authorities over EUR 150 million (Nuland and Cals 2000).

Such incidents have set large precedents for event-based recovery of costs. The "polluter pays" principle can be further extended through compliance markets, created so that cost externalities can be captured, securitized and capped in order to be traded amongst polluters who bear a market-determined price for covering their pollution costs. This is covered in the next section.

CREATING NEW MARKETS

New markets are already forming which support and reward biodiversity and ecosystem services. Some of them have the potential to scale up. But to be successful, markets need appropriate institutional infrastructure, incentives, financing and governance – in short, investment.

The state has traditionally been considered solely responsible for managing the public services of ecosystems, but it is now clear that markets can also contribute to this task, often without spending public money. Market-based approaches can be flexible and cost-effective – a feature that traditional conservation policies often lack. There are, however, difficulties because "environmental services markets" may be imperfect, sometimes lacking depth and liquidity, and with limited competition. Price discovery is often not easy, since most ecosystem services are public services, delivered widely and often remotely in the form of positive externalities. In some cases transaction costs could offset potential gains. Governments can help to remedy some of these shortcomings by providing an adequate institutional framework, for example by modifying liability rules, or capping resource use and issuing tradable permits to allow flexibility within the cap. The EU-ETS (European Union Emissions Trading Scheme for carbon credits) is a prime example of such a "compliance market". Governments can also facilitate private engagement to make ecosystem services visible, for example through labelling.

Mechanisms and financial products have been developed to deal with environmental liabilities. Habitat and species banks (see Box 4.4) are among the most innovative new instruments, providing tradable credits.

Box 4.4: Experience with habitat banking, endangered species credits and biobanking

In the United States of America, companies or individuals can buy environmental credits from Wetland Mitigation Banks to pay for degradation of wetland ecosystems due to agriculture or development activities. More than 400 banks had been approved by September 2005, almost three quarters of them sponsored by private entities, while in 2006 the trade of wetland bank credits reached an amount of US$ 350 million (Bean et al. 2007).

A biodiversity cap-and-trade system in the United States has created "endangered species credits", which can be used to offset a company's negative impacts on threatened species and their habitats. The market volume as of May 2005 was over US$ 40 million, with 930 transactions carried out and more than 44,600 hectares of endangered species habitat protected (Fox and Nino-Murcia 2005).

In 2006, Australia began a pilot project in New South Wales through the 2006 BioBanking Bill to create incentives for protecting private land with high ecological value (New South Wales Government 2006). The project resulted in developers buying "biodiversity credits" to offset negative impacts on biodiversity. These credits can be created by enhancing and permanently protecting land (Thompson and Evans 2002).

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Box 4.6: The Vittel example

The Vittel mineral water company (Nestlé Waters) was concerned about nitrate contamination caused by agricultural intensification so it began to pay farmers within its catchment to make their practices more sustainable. A key element of success was that Vittel gained the farmers' trust and maintained their income levels by providing them with sufficiently large payments. It also financed any required technological changes, meaning that farmers were not out of pocket. The company worked intensively with farmers to identify suitable alternative practices and mutually acceptable incentives.

Perrot-Maître 2006

Markets for products that are produced sustainably permit consumers to express their preferences for biodiversity and ecosystem protection in terms that businesses understand. Such markets are growing fast – markets for organic agriculture, certified food and timber products are growing three times faster than the average and the market for sustainably produced commodities could reach US$ 60 billion a year by 2010 (see The *Economist* 2005). In South Africa's Cape Floral Kingdom – a biodiversity hotspot home to nearly 10,000 plant species – wine producers who commit to conserving at least 10% of their vineyard are awarded "championship status" which they can advertise on product labels. They can also raise revenue from eco-tourism since the "Green Mountain Eco Route" was established in 2005 (Green Mountain 2008). Such certification and eco-labelling are popular market-based instruments, although possibly with less long-term potential than the banking and trading schemes described here (see Box 4.4).

Box 4.5: Panama Canal reforestation

Insurance firms and major shipping companies are financing a 25-year project to restore forest ecosystems along the 80-kilometre length of the Panama Canal. The Canal is the preferred shipping route between the Atlantic and Pacific Oceans, with more than 14,000 vessels passing through in 2007. But its operation is becoming increasingly affected by floods, erratic water supply and heavy silting as a result of deforestation of the surrounding land (Gentry et al. 2007).

The costs of maintaining the canal are rising, and there is a growing risk that it will have to close. Shipping companies faced increasing insurance premiums until ForestRe – a specialist insurance entity focused on forest risks – convinced them to fund ecosystem restoration (*The Banker* 2007). The advantages are less erosion and a more controlled flow of freshwater to the canal, which reduces insurance risk so that shippers enjoy lower premiums.

Businesses will also invest in ecosystem service management even if there are no direct products or reputational advantages, if the risks to the business of losing ecosystem services and the expected benefits are high enough. This makes a clear investment case on purely financial grounds for privately funded payments, as the Vittel-example demonstrates (see Box 4.6).

SHARING THE BENEFITS OF CONSERVATION

Protected areas could produce benefits from goods and ecosystem services worth between US$ 4,400 and 5,200 billion a year.

Balmford et al. 2002

A better understanding of the economics of ecosystem services is crucial to safeguarding and extending protected areas, showing how to realize and share their value with local communities without jeopardizing their biodiversity benefits.

More than 11% of the Earth's land surface is already legally protected thanks to a loose network of more than 100,000 protected areas (UNEP-WCMC/IUCN-WCPA 2008), which together contain most types of terrestrial biodiversity. The EU's Natura 2000 network is one example, accounting for around 20% of the EU-27 member territory (EU 2008).

But the protected area network is not complete and those that exist are under threat (Bruner et al. 2001) from a lack of both funding and political support. Importantly in the context of our work, protected areas face financial pressure


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because of the potential to make money from timber, meat, biofuels and other resources (CBD 2003, 2004; Terborgh 1999).

The economic values of conservation need to be better understood and made more explicit. Valuation can help to inform policy choices on creating or maintaining protected areas. Examples like the Gabčíkovo-Nagymaros Barrage System in Hungary show that if the value of biodiversity is measured against the benefits of large development projects, the chance of protecting sensitive areas increases. In this specific example, analysis showed that the natural capital involved far outweighed the benefit of the proposed dam project, which would have caused tremendous adverse impacts on biodiversity in the Szigetköz wetland areas (OECD 2001).

Local communities are the first to bear the costs of biodiversity loss. They should share the benefits of conservation.

Local communities as well as local governments typically look to achieve growth and economic development by attracting more people and businesses, promoting construction and infrastructure development. They may see protected areas as barriers to development, particularly where land is scarce and its use limited. The resulting costs of limiting land use are borne locally, but the benefits are likely to reach far beyond municipal borders.

This mismatch needs to be corrected, ideally by participation in the revenues from protected areas, as in Uganda (see Box 4.7). The costs of community-based conservation, such as livestock and crop losses, can be significant and need to be managed by communities, forest conservators and NGOs. Inadequate compensation for losses is a common refrain, although there are other recent examples of success (e.g. Bajracharya et al. 2008) where a survey of local residents concluded that the socio-economic benefits outweighed the costs.

Where the benefits are less direct than in the example above from Uganda, tax transfers between central, regional and local governments can provide local revenue that represents a share of ecosystem benefits. Brazil also demonstrates how this kind of financing works. Protected areas in the state of Paraná have been valued in intergovernmental payments to municipalities since 1992. Quality indicators which determine payments take account of conservation goals achieved. As a result, the number of protected areas increased and their quality improved. Similar models have been developed in 12 of the 27 Brazilian states and others are considering this approach (Ring 2008).

Box 4.7: Protected areas in Uganda

Since 1995 Ugandan legislation places the management of natural resources in the hands of local authorities. Consequently the Ugandan Wildlife Authority (UWA) disburses 20% of all revenues from protected area (PA) tourism to the local communities neighbouring the PAs. This percentage has been fixed without a precise picture of PA economics, but even a rough approximation of costs and benefits allows local livelihoods to be enhanced while preserving biodiversity. Of course such a benefit-sharing regime only works in the long run if it actually compensates for the use-restrictions that PAs imply for local communities. Thus, knowing better the costs and benefits involved will allow reconciling ongoing biodiversity conservation and enhancing rural livelihoods (Ruhweza 2008).

Some protected areas placed under the "Revenue Sharing Programme" of the Ugandan Wildlife Authority

Bwindi Impenetrable National Park
Mgahinga Gorilla National Park
Lake Mburo National Park
Queen Elizabeth National Park
Rwenzori Mountains National Park
Kibaale National Park
Semliki National Park
Murchison Falls National Park
Mount Elgon National Park

Population trends of selected species in Lake Mburo National Park

Species	1999	2002	2003	2004	2006
Zebra	2,249	2,665	2,345	4,280	5,986
Buffalo	486	132	1,259	946	1,115
Waterbuck	598	396	899	548	1,072
Hippo	303	97	272	213	357
Impala	1,595	2,956	2,374	3,300	4,705

Source: UWA 2005

In Europe, Portugal has led the use of intergovernmental fiscal transfers to municipalities for Natura 2000 areas that relate to the EU Habitats and Birds Directives.

The costs of loss and degradation relate to how much local communities depend on biodiversity and ecosystem services. Many indigenous communities are utterly dependent for survival on their local resources. Especially in such cases, "community-conserved areas" based on traditionally sustainable resource-use systems are a further alternative and can be more effective than conventional protected areas (IUCN 2008). They could have governance structures that are adapted to local needs as well as the local skills and knowledge available.

Valuing and sharing the benefits of biodiversity and ecosystem services can thus help biodiversity protection policies to better address the needs of local communities. **If benefits mainly occur beyond the local level, transfers can reward communities' efforts and help them find the resources needed for the protection of biodiversity and the provision of ecosystems services.**

WHAT ECOSYSTEM AND BIODIVERSITY ECONOMICS CAN OFFER TO PROTECTED AREAS

A better understanding of biodiversity economics will help to:

- Create cashflow: protected areas' chronic funding shortages totalled US$ 38.5 billion in 2001 (Balmford et al. 2002). Quantifying the financial and non-financial benefits of ecosystems is key to tapping private funding and generating income for protected areas by realizing payments for ecosystem services.

- Gain political support: clarity about the economic benefits of maintaining ecosystem services could increase political support to match that typically achieved for sectors such as agriculture, industrial development and regional planning.

- Improve policy making: introducing values for biodiversity and ecosystem services will support better policy decisions about land use, based on quantifying the effects of decisions and allowing evaluation of trade-offs between options, for example levels of grazing or wood extraction.

- Improve the governance structures: protected areas are often managed according to blueprints without taking into account the distribution of relevant competences and the concerns of those most affected by protection. A better understanding of the costs and benefits of conservation and use of biodiversity can help to improve the distribution of responsibilities in management (Birner and Wittmer 2004).

MEASURING WHAT WE MANAGE: METRICS FOR SUSTAINABILITY

"Because National Accounts are based on financial transactions, they account nothing for Nature, to which we don't owe anything in terms of payments but to which we owe everything in terms of livelihood."

Bertrand de Jouvenel 1968

Our economic compass is defective because of unaccounted externalities at every level – national, corporate and individual. Here we summarize work in progress to correct this failure, and describe how we can contribute in Phase II.


Aditi Halder, Confederation of Indian Industry

The inadequacy of national accounting has been recognized for at least 40 years (see box below). It is now essential to aim "beyond GDP" as inadequate metrics have cost us dearly in terms of unsustainable growth, degraded ecosystems, lost biodiversity, and even reduced per-capita human welfare, especially in developing countries.

In November 2007, the European Commission, the European Parliament, the Club of Rome, WWF and the OECD held a major conference in Brussels called Beyond GDP. It was attended by 650 policy makers and opinion leaders from all over the world. It focused on the need for more than GDP as a measure of what society values, highlighted by the fact that devastation by events such as Hurricane Katrina and the Asian tsunami show up as increases in GDP despite the human tragedies and property losses.

The conference consensus was that we needed to add environmental and social measures to the existing GDP metric (Beyond GDP 2007). Targeting solely for classical GDP growth may not be of much help with many of our pressing problems. For example, it may not be able to solve persistent poverty in Africa and Asia, nor equip us to tackle climate change and unsustainable development.

The call for action comes not just from policy makers and

Courtesy of European Parliament

experts, but also from the public. In a survey (GlobeScan 2007) on measures of progress beyond GDP, three-quarters of those asked (in 10 countries including Australia, Brazil, Canada, France, Germany and Russia) concluded that governments should *"look beyond economics and include health, social and environmental statistics in measuring national progress"*.

The widely used System of National Accounts (SNA) does not recognize many significant externalities in the areas of natural resources, health and education. This means that desirable improvements in health and education are accounted for as expenses instead of investments. Valuable ecosystem services which are income sources are not recognized at all and deforestation is not recorded as a form of depreciation.

Managing improvements in health, education and quality of environment without a formal framework to value them financially can be a frustrating exercise. Sub-optimal policy choices and trade-offs are likely in the absence of a "sustainability yardstick". The publication of a "genuine savings" indicator for many years by the World Bank showed that adding to the GDP metric was indeed possible at a global level (World Bank 2008). However, the usefulness of this metric was limited by its need to capture minimum standards in data collected across all countries, thus limiting the range of natural capital adjustments which could be included in computing genuine savings.

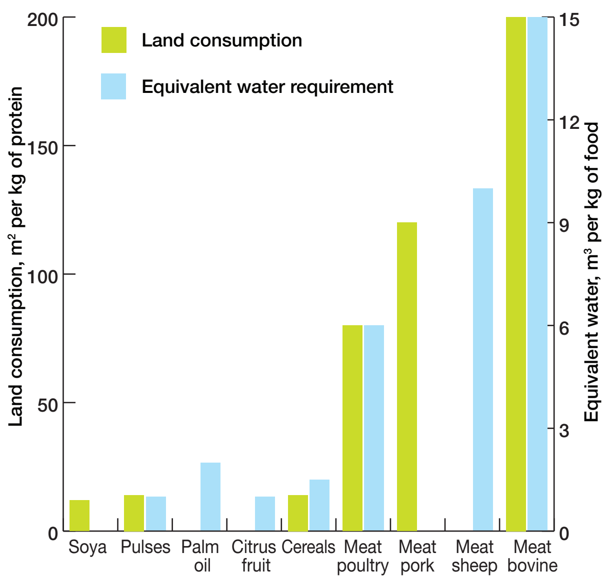
Developing a more inclusive national income and wealth accounting (NIWA) metric should be a priority, especially for countries most prone to ecosystem and biodiversity losses. It could make the difference between a viable and sustainable economic trajectory and one which spells disaster not just for developing countries but for us all.

The United Nations' System of Integrated Environmental and Economic Accounting (UNSD 2008) can be a starting point for preparing holistic national income and wealth accounts that reflect externalities in the areas of natural resources, health and education. At present, few countries produce holistic national income statistics on this basis, and there is no comparability because different areas are covered, different externalities captured, and there are varying degrees of granularity.

A revision of the SNA 1993 is currently being finalized by the UN Statistical Commission, involving many key organizations including UNEP, the World Bank, IMF, OECD, European Commission and statistical offices around the world. We understand that an important component of the SNA revision is the recognition of an enhanced version of the SEEA as a standard. The ongoing SEEA revision process, initiated by the UN Committee of Experts on Environmental-Economics Accounting (UNCEEA) Bureau, is a timely and necessary step for national income metrics to progress "beyond GDP". We believe that ecosystems, biodiversity and their valuation deserve particularly close attention. **It is very important that the development of ecosystem/biodiversity accounting in physical and monetary terms is promoted as a key early priority of the ongoing SEEA revision, building on the work of EEA and others.**

At the corporate level, too, there is gradual recognition of the need to redefine corporate success, and enhance performance measurement and reporting to reflect a broader vision for the corporation than just an optimizer of financial capital for its shareholders. "Triple bottom line" and sustainability reporting disciplines are being followed by an increasing number of corporations. The Global Reporting Initiative (GRI) has issued detailed guidelines on

Figure 4.1: Land and water use of various foods



Source: United Nations World Water Assessment Programme (2003) sustainability reporting. The Carbon Disclosure Project has been successful in eliciting voluntary disclosure from an increasing number of corporations and countries year after year. All these initiatives are, however, based on voluntary disclosure, and are not followed widely enough to be considered market standards.

In Phase II we will reach out to organizations involved in redefining corporate performance metrics and reporting standards as we intend to evolve valuation guidance on corporations' use of natural capital, including carbon footprint measurement.

Consumers are a major source of pressures to convert natural ecosystems to other land uses, especially through demand for food. Different kinds of foods have dramatically different ecological footprints (see Figure 4.1). It is difficult for consumers to incorporate these factors in purchasing choices unless the products they buy – especially food – clearly disclose their ecological footprint at the point of sale. A credible standard methodology is a basic prerequisite, which we shall explore further with end-user groups in Phase II. **The goal is to identify or evolve standard metrics for consumer footprint (in terms of land, water and energy use) which are based on sound ecology and economics simple enough to understand and to be implemented by retailers.**

IMAGINING A NEW WORLD

It is gradually becoming accepted that healthy ecosystems maintaining high levels of biodiversity are more resilient to external pressure and consequently better able to sustain the delivery of ecosystem services to human society. Countries and more and more companies and citizens want to know and understand the reality of the costs of using the Earth's natural capital and the consequences of policies on the resilience and sustainability of ecosystems.

We still face many gaps in knowledge on the status and trends of biodiversity and the drivers and pressures that contribute to its loss, but the scenarios we have outlined on the projected loss of biodiversity, ecosystems and ecosystem services point firmly to the high risk of further losses to human well-being and development.

This chapter has highlighted different approaches to replace society's defective old economic compass and then to use the new one: to rethink today's subsidies, to design policies and market structures which reward unrecognized benefits and penalize uncaptured costs, and to share the benefits of conservation and protected areas in a more equitable manner. Parts of the evolving toolkit of new economics and policies are already in place in some countries or regions, yet others are still under development with initial case studies showing their potential, but overall a lot more needs to be done.

André Künzelmann, UFZ

Imagine now that these measures were not only applied in pilot schemes or single countries. Imagine the tiny seeds planted now growing to majestic trees. Imagine how they can contribute to improved quality of life in the 2030s and beyond.

Imagine the growth of human well-being and security that is not based on higher and higher per-capita GDP and ever-more serious climate and ecosystem disasters hitting the headlines every morning.

Imagine a secure and stable world with universal access to clean water and healthy food, with equity in access to education and income opportunity, and with social and political security – a world meeting and even going beyond the Millennium Development Goals.

Biodiversity and ecosystem services are now recognized as vital infrastructure to achieve human welfare and well-being. We are convinced that The Economics of Ecosystems and Biodiversity, if used with careful consideration of the underlying ethical choices, can make decisive contributions towards safeguarding biodiversity and ecosystem services and improving well-being for us and for generations to come.

> **"Another world is not only possible, she is on her way. On a quiet day, I can hear her breathing."**
>
> Arundhati Roy, author of *The God of Small Things*, at the World Social Forum, 2003

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AN OUTLINE OF PHASE II

Phase II of The Economics of Ecosystems and Biodiversity (TEEB) study sets out to continue the work initiated in Phase I and will seek to achieve five important goals. These are to:

- Firm up a "science and economics framework" integrating ecological and economic knowledge to structure the evaluation of ecosystem services under different scenarios.

- Identify "recommended valuation methodologies", applicable under differing conditions and data assumptions to the most tangible and significant economic values of biodiversity and ecosystem services, across the world's main biomes.

- Examine the economic costs of biodiversity decline and the loss of ecosystem services worldwide in a business-as-usual scenario and the costs and benefits of actions to reduce these losses in alternative scenarios, focusing on a medium- to long-term perspective.

- Develop a "policy toolkit" which supports policy reforms and integrated impact assessment to ensure that all relevant information is considered to analyse the pros and cons of different options, in order to foster sustainable development and better conservation of ecosystems and biodiversity.

- Engage key "end-users" at an early stage to ensure that the output of this study is relevant to their needs, accessible, practical, flexible and, overall, useful.

To understand what these goals mean for the scope of the work in Phase II, some of the considerations involved are outlined below, as well as key points to be covered and tasks to be carried out:

1 **Science and economics framework:** the conceptual framework as set out in Chapter 3 will be elaborated further to serve as a practical basis for the evaluation. A classification of ecosystem services structured around an end-user perspective will be proposed. The review of the state of ecological knowledge will need to be complemented for the ecosystem services not covered in Phase I. Building on this review, methods will be defined for the (spatially explicit) assessment of the provision of ecosystem services in biophysical terms under different scenarios, upon which to base the economic valuation. Due attention will be given to addressing risks and uncertainties associated with ecological processes as well as human behaviour, and to analysing the consequences of applying different discount rates in the calculation of benefits and costs.

2 **Valuation methodologies:** the extensive literature on methodologies will be assessed further, making use of submissions received in reply to our call for evidence in Phase I. Some biomes (e.g. oceans) and some values (e.g. option values and bequest values) which were not addressed in depth in Phase I will be evaluated further. Phase II work will indicate preferred valuation methodologies appropriate for use under different conditions determined by biome classes, economies, and socio-political contexts. It will look at the strengths and weaknesses of different techniques, assessing their degree of applicability and their data requirements. The key challenges identified in Chapter 3 of this report will need to be addressed. This includes defining a methodology for benefit transfer and for aggregation which should be both credible and appropriate for large-scale assessments. Phase I also illustrated the value of using biophysical indicators to build metrics from the ecological to the economic layers (e.g. MSA – Mean Species Abundance – used in the Cost of Policy Action (COPI) study) and Phase II will further evaluate available qualitative and quantitative measures which exhibit potential use for policy formulation, targeting and oversight, as well as economic assessments.

3 **Costs of policy inaction, and policy costs:** a global assessment of the net economic consequences of inaction and of actions to reduce the loss of biodiversity and ecosystem services will be completed, making use of the valuation literature and of previous large-scale assessments and global scenarios, including the COPI study carried out in Phase I. However, to be meaningful, a global assessment cannot be reduced to a single quantification exercise and will need to be complemented by more disaggregated levels of analysis, which are relevant for decision making.

4 **Policy toolkit:** recognizing the central importance of policy action, a policy toolkit will be developed, building on a review of policies that are already working in some countries and appear to have the potential to be scaled up locally or replicated elsewhere. This toolkit should be relevant around the world, so that policy makers from any country could find something useful. It should in all cases be illustrated with the associated economics. For example, the economics of protected areas will form a particular focus: the economic value of protected areas is at present not adequately recognized and policy enforcement is neither sufficiently robust nor adequately funded. Phase II will aim to demonstrate how policies can be changed when we are able to better take into account biodiversity values to people and to reconstruct society's broken compass.

5 **End-user interfaces:** to succeed on a global scale, alliances are needed across all sectors of society. Links should be established with key stakeholders such as the groups in charge of improving the System of Integrated Environmental and Economic Accounting (SEEA-2003), and the evolving institutional network of projects addressing the greening of economies (e.g. UNEP), the greening of national accounting (e.g. United Nations Committee of Experts on Environmental Economic Accounting – UNCEEA), the funding of protected areas (e.g. PA Network), and the development of payments for ecosystem services. Likewise, it would appear useful to engage with on-going efforts to enhance corporate performance reporting to include sustainability considerations (e.g. Global Reporting initiative – GRI), consumer organizations at the forefront of greening consumer choice, and governments involved in similar initiatives (through computing consumer goods footprints, point-of-sale disclosures, etc.).

Biodiversity must become the responsibility of everyone with the power and resources to act. Phase II therefore aims to provide policy-relevant information to inform and accelerate better policies that support conservation and sustainable use of biodiversity in all regions of the world and feed into the development of new “sustainability” metrics to complement the familiar metrics of GDP growth and corporate profitability. The first steps are taken, and we are confident the final report on TEEB planned for Phase II will be a work appreciated and valued by all our end-users.

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ECOSYSTEM ACCOUNTING FOR THE COST OF BIODIVERSITY LOSSES: FRAMEWORK AND CASE STUDY FOR COASTAL MEDITERRANEAN WETLANDS – coordinated by EEA, using a grant provided by BMU

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A variety of reports, articles and other contributions have been received in reply to the web-based call for evidence organized by the European Commission, and will also be used in Phase II. We would like to thank all the respondents to this call.

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Note: some of the contributors responded to the call on own account.

Finally, over 90 experts in economics, ecology, and policy participated in the workshop on the economics of the global loss of biological diversity held on 5-6 March 2008, Brussels. We are very thankful for the ideas provided and the set of recommendations on the way forward developed. The proceedings of the workshop and the presentations made are available on the TEEB website: http://ec.europa.eu/environment/nature/biodiversity/economics/index_en.htm as well as at the following link: http://www.ecologic-events.de/eco-loss-biodiv/index.htm.

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SYNOPSES OF STUDIES

COST OF POLICY INACTION (COPI): THE CASE OF NOT MEETING THE 2010 BIODIVERSITY TARGET

Braat L. (Alterra) and ten Brink, P. (IEEP) et al, May 2008 (for DG Environment, European Commission)

The study presents the impacts of global economic development according to the OECD baseline scenario (OECD March 2008) on biodiversity on land and in the oceans, on the associated ecosystem services and on economic and social systems, in quantitative and monetized terms. Building on modelled future change in biodiversity (Global Biodiversity Outlook 2, CBD 2006) and the Millennium Ecosystem Assessment (2005), the annual global and regional welfare losses due to decreased biodiversity and loss of ecosystem services have been calculated. The study is exploratory, identifying preliminary numbers as to the scale of the impacts and the economic importance of addressing biodiversity loss, and clarifying methodological approaches for a wider analysis of its implications for welfare and well-being.

REVIEW ON THE ECONOMICS OF BIODIVERSITY LOSS: SCOPING THE SCIENCE

Balmford, A., Rodrigues, A. (University of Cambridge), Walpole, M. (WCMC), ten Brink, P., Kettunen, M. (IEEP), and Braat, L. and de Groot, R. (Alterra), May 2008 (for DG Environment, European Commission)

This study encompassed two main tasks. Firstly, it developed a conceptual framework for estimating the net economic consequences of policy actions to conserve biodiversity and ecosystems. This framework, which can be used as a tool for testing policy packages at a diversity of spatial scales, relies on the spatial assessment of the variation in the marginal benefits and costs of biodiversity conservation. The second main task in this study was a coherent overview of existing ecological knowledge, upon which to base the economics of the review. For a diversity of ecological processes (e.g. pollination, water regulation) and benefits (e.g. fisheries, wild meat) the project reviewed the literature and consulted with experts to understand: the relationship with human well-being; how biodiversity loss and ecosystems degradation are likely to influence the provision of each process or benefit, including in terms of long-term resilience; what challenges such provision faces; and what are the current trends. Crucially, this review also investigated how far current knowledge is from being able to quantify and map, at the global scale, estimates of the production of each process or benefit, upon which a spatially explicit economic valuation can be based. A mixed picture emerged, with some areas sufficiently advanced in knowledge to form the basis of the economic valuation, while for others substantially more research is needed.

REVIEW ON THE ECONOMICS OF BIODIVERSITY LOSS: ECONOMIC ANALYSIS AND SYNTHESIS

Markandya, A., Nunes, P.A.L.D. (FEEM), Brauer, I. (Ecologic), ten Brink, P. (IEEP), and Kuik, O. and Rayment. M. (GHK), April 2008 (for DG Environment, European Commission)

This report reviewed the set of articles and other submissions that responded to the European Commission's "call for evidence". A hundred and sixteen contributions were received from 55 participants. The main message is that we are witnessing a progressive loss of biodiversity and that this is the cause of significant welfare damages. Secondly, economic valuation of changes of biodiversity losses can make sense – when a clear diversity level is chosen, when a concrete scenario for biodiversity change is formulated, when changes are within certain boundaries, and when the particular perspective on biodiversity value is made explicit. The call for evidence also clarified that there is a range of gaps in the coverage of the valuation literature, for example, the value of indigenous knowledge in the conservation of biodiversity is under-researched, as is the biodiversity value of marine resources, especially deep sea resources, and also the valuation of genetic material. In addition, the review also concludes that estimates of economic values should be considered at best as lower bounds to unknown values of biodiversity. Priorities for research are to carry out more case studies of biodiversity loss and practical ways of dealing with it at the country level, and to explore existing valuation data and value transfer techniques. Most importantly, biodiversity should not remain an isolated "environment" issue and its importance in the context of economic and other global issues, such as climate change, should be further analysed.

STUDY ON THE ECONOMICS OF CONSERVING FOREST BIODIVERSITY

Kontoleon, A. et al., University of Cambridge, Dept of Land Economy, March 2008 (for IUCN)

This meta-study examines the evidence from existing case studies on the benefits and costs of protecting forest biodiversity to assess the extent to which these values can aid decision making about biodiversity policy; and to identify information gaps. The review covers almost 200 studies that value a number of benefits arising from forest biodiversity, and 40 studies that estimate the costs of conserving forest biodiversity. All forest types are covered, although studies relating to forests with significant biodiversity value are prioritized. All geographical locations for which evidence is available are covered, and the individual studies include a mix of global, regional, national and local estimates. The study also assesses alternative policy and finance options for conserving forest biodiversity: protected areas, land-use regulations and technology mandates; incentives such as user fees and subsidy payments; and market-enabling instruments such as certification schemes.

ECOSYSTEM ACCOUNTING FOR THE COST OF BIODIVERSITY LOSSES: FRAMEWORK AND CASE STUDY FOR COASTAL MEDITERRANEAN WETLANDS

An EEA - European Environmental Agency study, March 2008 (Phase I)

The purpose of the case study on Mediterranean wetlands was to demonstrate both the feasibility of ecosystem accounts and their interest for policy making. The questions behind ecosystem accounts relate to the sustainability of ecosystem assets use, to the amount to reinvest in maintenance and restoration in order to keep ecosystem functions and services in the future and to the value of the non-market services currently not recorded in households' private or collective consumption, and therefore not considered as a component of their well-being. The main findings include: accounting has to be carried out for socio-ecological systems dominated by wetlands, not at a smaller level; ecological functions and ecosystem services values need to be measured at three different scales: micro, meso and macro, in order not to miss high-value regulating services; at the micro scale, accounting charts could be usefully promoted for the needs of the local actors; at the global scale, macroscopic accounts of ecosystem potentials can be undertaken shortly with the support of Earth observation programmes; at the meso scale (countries, regions) further development of accounts should be undertaken within the ongoing revision process of the UN System of Economic Environmental Accounting.

Detailed information with regard to these studies can be found at:
http://ec.europa.eu/environment/nature/biodiversity/economics/index_en.htm

CORRIGENDUM

Chapter 1

Page 12 left column first bullet: data for forest loss was drawn from Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Current State and Trends*. Island Press Washington D.C. URL: http://www.millenniumassessment.org/documents/document.290.aspx.pdf

Page 12 right column first bullet: the numbers for the loss of wetlands since 1900 are estimated by OECD – Organisation for Economic Cooperation and Development and IUCN – International Union for Conservation of Nature (1996) *Guidelines for aid agencies for improved conservation and sustainable use of tropical and sub-tropical wetlands*. OECD, Paris.

Page 12 right column second bullet: Wilkinson (2004) estimates that 20% of the world's coral reefs have been effectively destroyed and show no immediate prospects of recovery. Furthermore, his report predicts that 24% of the world's reefs are under imminent risk of collapse through human pressures; and a further 26% are under a longer term threat of collapse.

Chapter 2

Page 15 right column: Data for the food price development is taken from IFPRI – International Food Policy Research Institute (2008) *Rising Food Prices: What should be done?* IFPRI Policy Brief April 2008. URL: http://www.ifpri.org/publication/rising-food-prices

Page 16 right column: Reference for the 'dependence of more than 1 billion people on fish as their main source of animal protein' is: Berkes, F., Mahon, R., McConney, P., Pollnac, R. and Pomeroy, R. (2001) *Managing small-scale fisheries; Alternative Directions and Methods*. IDRC, Ottawa, Canada. URL: http://www.idrc.ca/en/ev-28113-201-1-DO_TOPIC.html

Page 17 Box 2.2: The claim 'coral reefs have been reduced by 80% in three decades' is made in the paper by Gardner, T. A., I. M. Cote, et al. (2003). Long-Term Region-Wide Declines in Caribbean Corals. *Science* 301(5635): 958-960.

Page 17 left column: The reference for 'Global warming melts the glaciers that feed Asia's biggest rivers in the dry season – precisely the period when water is needed most to irrigate the crops on which hundreds of millions of people depend' is Barnett, T. P., Adam, J. C. and Lettenmaier, D. P. (2006): Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature* 438: 303-309.

Page 18 left column first and second bullet point: both calculations are provided in the paper by Newman and Cragg 2007 that is cited in the report.

Page 18 left column third bullet point: There is a rough estimation on the number of plant species used for treatment in China given by Sharma, M. (no date) *Appreciating the benefits of plant biodiversity based drugs in treatment of various ailments / microbial infections*. URL: http://hillagric.ernet.in/edu/covas/vpharma/winter%20school/lectures/2%20Appreciating%20benefits%20of%20plant%20biodiversity.pdf.

Page 18 left column fourth bullet point: the data on use of traditional medicine is drawn from WHO – World Health Organization (2008) Traditional medicine. Fact sheet 134. URL: http://www.who.int/mediacentre/factsheets/fs134/en/.

Page 18 right column first bullet point: data for market size of pharmaceuticals taken from ten Kate, K. and Larid, S. A. (1999) *The commercial use of biodiversity: Access to Genetic Resources and Benefit-sharing.* Earthscan, London.

Page 18 right column second bullet point: Steven T. DeKosky, S. T., Williamson, J. D., Fitzpatrick, A. L., Kronmal, R. A., Ives, D. G., Saxton, J. A., Lopez, O. L., Burke, G., Carlson, M. C., Fried, L. P., Kuller, L. H., Robbins, J. A., Tracy, R. P., Woolard. N. F., Dunn, L., Snitz, B. E. Nahin, R. L., Furberg, C. D. (2008) Ginkgo biloba for Prevention of Dementia: A Randomized Controlled Trial. *The Journal of the American Medical Association* 300 (19): 2253-2262 state that in 1999 global sales of Gingko biloba exceeded U$249 millions (in contrast to U$ 360 million as stated in the Interim Report) based on statistics of The Nutrition Business Journal (2006) *Supplement Business Report 2006*. San Diego, CA Penton Media Inc.

Page 19 Map 2.2: Strassburg et al. refs is missing in the bibliography: Strassburg, B., Turner, K., Fisher, B., Schaeffer, R. and Lovett, A. (2008*) An Empirically-Derived Mechanism of Combined Incentives to Reduce Emissions from Deforestation*. CSERGE Working Paper ECM 08-01. URL: http://siteresources.worldbank.org/EXTCC/Resources/407863-1213125462243/5090543-1213136742584/ECM0801Strassburgetal.pdf .

Page 19 right column: The Millennium Ecosystem Assessment (2005b, p. 10) states that 'approximately one quarter (24%) of Earth's terrestrial surface has been transformed to cultivated systems'.

Page 24 right column first bullet point: The aggregated estimate based on a compilation of regional data is provided by Bryant, D., Burke, L., McManus, J. and Spalding, M. (1998) *Reefs at Risk: A Map- Based Indicator of Threats to the World's Coral Reefs*. World Resources Institute, Washington DC.

Chapter 3

Page 36 Box 3.6: Coral reefs, which directly support fisheries that constitute 9–12% of the world's total fisheries (up to 25% in some parts of the Indo-Pacific), providing livelihoods for millions of people in tropical coastal regions (Balmford et al. 2008). A large number of offshore fisheries also rely on the supporting services of reefs as breeding, nursery or feeding grounds (Moberg, F. and Folke, C. (1999). Ecological goods and services of coral reef ecosystems. *Ecological Economics* 29: 215-233; Agardy, T., Alder, J., Dayton, P., Curran, S., Kitchingman, A., Wilson, M., Catenazzi, A., Restrepo, J., Birkeland, C., Blaber, S., Saifullah, S., Branch, G., Boersma, D., Nixon, S., Dugan, P. (2005) Coastal Systems. *Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Current States and Trends*. Washington D.C., USA: World Resources Institute: pp. 515-543).

Chapter 4

Page 47 Box 4.1: Definitions can be found in OECD – Organisation for Economic Cooperation and Development (1998) *Improving the Environment through Reducing Subsidies*. OECD, Paris and OECD – Organisation for Economic Cooperation and Development (2005) *Environmentally Harmful Subsidies: Challenges for Reform*. OECD, Paris.

Page 49 left column: More recent research suggests that tropical deforestation and drainage of peatlands account for 15% of total global greenhouse gas emissions, see van der Werf, G. R., Morton, D. C., DeFries, R. S., Olivier, J. G. J., Kasibhatla, P. S., Jackson, R. B., Collatz, G. J. and Randerson, J. T. (2009) CO2 emissions from forest loss. *Nature Geoscience* 2(11): 737-738.

Page 50 left column second bullet: Clean-up and restoration costs are estimated to be even more than 180 million EUR, see the evidence collected by CEA (2007): *White Paper on Insurability of Environmental Liability*. URL: http://www.cea.eu/uploads/DocumentsLibrary/documents/Mail%20-%20CEA%20White%20Paper%20on%20Insurability%20of%20Environmental%20Liability.pdf.

Page 50 Box 4.4: More recent data for number of banks, market size and financial volume of transactions can be found in Madsen, B.; Carroll, N. and Moore Brands, K. (2010): *State of Biodiversity Markets Report: Offset and Compensation Programs Worldwide*. URL: http://www.ecosystemmarketplace.com/documents/acrobat/sbdmr.pdf.